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# An Evaluation of Hydrologic and Riparian Resources in Saguaro National Park, Tucson, Arizona

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# **Executive Summary**

#### SETTING:

Within Saguaro National Park only Rincon Mountain District contains significant riparian areas. The geologic framework of the Tanque Verde Ridge and Rincon Valley exerts strong control on the hydrology of these riparian systems. Pantano fault constitutes a line of hydrogeologic separation between the occurrence and utilization of groundwater in the Rincon Valley and the main Tucson basin. No known, comparable fault isolates the upper Tanque Verde Creek alluvium from downstream pumping effects. However, east of the confluence with Agua Caliente Wash, the highly permeable alluvial materials are much thinner, and serve to dampen such downstream effects. Therefore, the ground water reservoirs supporting the riparian areas within Rincon Mountain District are not directly connected to the Tucson basin aquifer.

In what is described herein as upper basin areas, high gradient tributary streams to Tanque Verde Creek and Rincon Creek have discontinuous bodies of shallow alluvium interspersed with bedrock channel. Alluvium has accumulated behind small faults or resistant bedrock ledges and contains shallow ground water basins that support small pockets of riparian or xeroriparian vegetation. The ground water in these small basins is sustained by seeps or springs, and by runoff from precipitation and is not likely to be connected to a regional ground water system.

In what we have characterized as middle basin areas, the stream gradients are less than 25m/km. In these low gradient reaches, the alluvial floodplain sediments are continuous, though not thick, as ledges of more resistant bedrock formations appear in the stream channel. These low gradient reaches contain larger volumes of ground water than the high gradient basins and support more robust riparian vegetation. The ground water in the low gradient reaches is believed to be connected to the regional ground water system. Such a low gradient reach exists in a tributary to Tanque Verde Creek about 1.4 km east of Wentworth Road and extends about 1.6 km into the Park. A similar low gradient reach occurs along Rincon Creek in the Expansion Area, and at the mouths of Chiminea and Madrona Creeks.

#### **EXISTING RIPARIAN CONDITIONS:**

The high gradient tributaries of Rincon and Tanque Verde Creeks support a combination of mixed narrow leaf community dominated by such species as mesquite, catclaw, desert willow, and mixed scrub. Considered a xeroriparian community, this habitat type is an important resource to the Park. Below 1000 meters, these reaches are dominated by a more typical riparian community of sycamore and cottonwood.

The lower portions of Chiminea, Madrona and Rincon Creek through the X9 ranch area to Sentinel Butte support the finest and most extensive riparian habitat remaining in the Park. At these lower elevations, the stream channels widen slightly and modest deposits of saturated alluvium supply limited groundwater storage capacity to the system. This allows for the development of a band of riparian habitat dominated by cottonwoods, willows, and sycamores along the streambank. This stretch of habitat is



one of two areas critically threatened by increased groundwater development. The second threatened habitat is the mesquite bosque growing along the northern boundary of the Park in a tributary of Tanque Verde Creek. This bosque is supported by flows from several tributaries as they converge just above their confluence with Tanque Verde Creek.

These habitats posses high wildlife values and are crucial to the functioning of Saguaro National Park. The long-term health and survival of these habitats depends upon an assured groundwater source for daily water requirements and a natural surface flooding regime for recruitment events. However, current groundwater development is placing considerable stress upon these systems. Field investigations reveal signs of water stress in mature trees, as well as a lack of seedling/sapling recruitment. This coupled with the transition to a more xeric community that is occurring away from the creek bank should be taken as a serious warning signal.

#### THREATS:

The principal threats to the upper basin riparian areas in order of severity are: (1) Prolonged drought resulting in the drying up of springs and seeps and a reduction in surface runoff to replenish the ground water. (2) Hillslope erosion along the lateral edges of the small basins depositing sediment in the riparian areas thus raising the land surface above the water table. (3) Trespass livestock.

The principal threats to the middle basin riparian areas are: (1) The possible development of increased ground water withdrawals from the floodplain alluvium or aquifers which are in hydraulic connection with that aquifer. (2) The continuation of present ground water withdrawals in these areas.

#### **MANAGEMENT ALTERNATIVES:**

The passive management alternative includes the implementation of monitoring programs to detect changes in the ground water levels of the middle basin riparian areas. In both the middle and upper basin areas, transects should be established to monitor the health of the riparian vegetation and evaluate the accumulation of sediments.

Pro-active management alternatives include: (1) Taking legal and/or administrative actions to prevent further development of ground water supplies in the middle basin areas. (2) Encouraging expansion of the Tucson Water Service Area to include the middle basin areas of both Tanque Verde and Rincon Creeks bringing an additional source of water to augment the natural supply. (3) Encourage retention of septic systems and leach fields in the middle basin areas to keep natural and any additional water supplies contributing to ground water replenishment. (4) Investigate the feasibility of using treated waste water from a regional treatment plant to augment ground water recharge at the upstream ends of the middle basin reaches.



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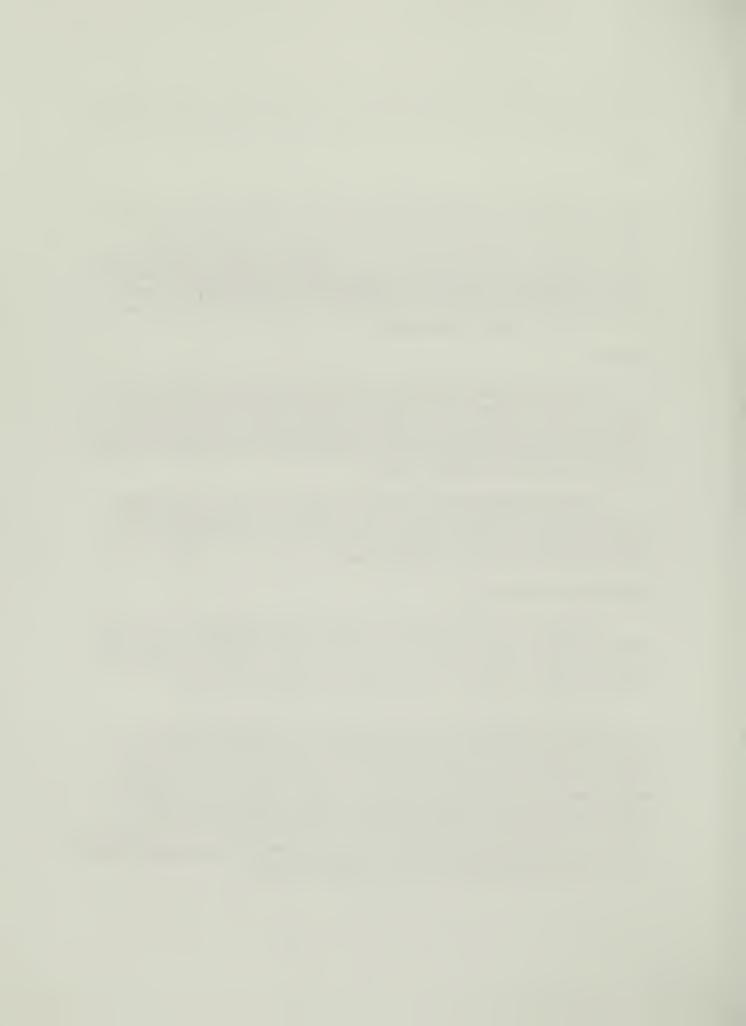
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#### INTRODUCTION

Saguaro National Park in Tucson, Arizona encompasses two geographically distinct areas: Rincon Mountain District and Tucson Mountain District. Of the two, only the Rincon Mountain District (Park) has significant riparian habitat due to Tanque Verde Ridge, which reaches 2641 meters in elevation. The higher elevations in this area receive more precipitation than the basin floor and the Tucson Mountain District area. The runoff from the precipitation infiltrates the alluvial materials covering the floors of the washes draining Tanque Verde Ridge and sustains riparian corridors in the middle reaches of Tanque Verde and Rincon Creeks. The scope of this study includes Rincon Creek, its tributary riparian areas and Tanque Verde Creek riparian tributary areas within or immediately adjacent to the Park (Mac Nish and Guertin, 1997). Both of these creeks have riparian resources that will likely be impacted by proposed development adjacent to the Park boundaries.

The Rincon Creek watershed is located in Rincon Valley on the southwest side of the Rincon Mountains. It is formed by Tanque Verde Ridge and Mica Mountain to the north and Rincon Peak to the east and drains about 19,100 hectares. The Rincon Creek drainage area covers about one third of the Rincon Mountain District. Approximately one half of the Rincon Creek watershed lies within Saguaro National Park, while a small portion on the eastern end is located in Coronado National Forest (Briggs et al., 1996).

Rincon Creek drains a large portion of the southwestern side of the Rincon Mountains and borders Saguaro National Park along its southern edge (Figure 1). It flows almost due west through the Rincon Valley to its confluence with Pantano Wash. Short reaches of Rincon, Madrona, and Chimenea Creeks flow from park land, across private land and enter the Park's expansion area (Briggs et al., 1996). Within the expansion area, Rincon Creek is intermittent or ephemeral. However, the high groundwater table in portions of the expansion area supports good quality riparian habitat along its banks.

Tanque Verde Creek flows for 25 km from its headwaters in the Rincon Mountains to its confluence with Pantano Wash. The lower ten-kilometer stretch of Tanque Verde Creek is a relatively low gradient ephemeral creek. Remnant mesquite bosques line the wide sandy channel (Stromberg et al., 1992). With a mean elevation of 1,323 meters, Tanque Verde basin receives a mean annual precipitation of 424.2 mm. While Tanque Verde Creek proper lies outside of Saguaro National Park, numerous tributaries lie within the Park. Several of these tributaries support important riparian/mesquite bosque communities (Figure 2).



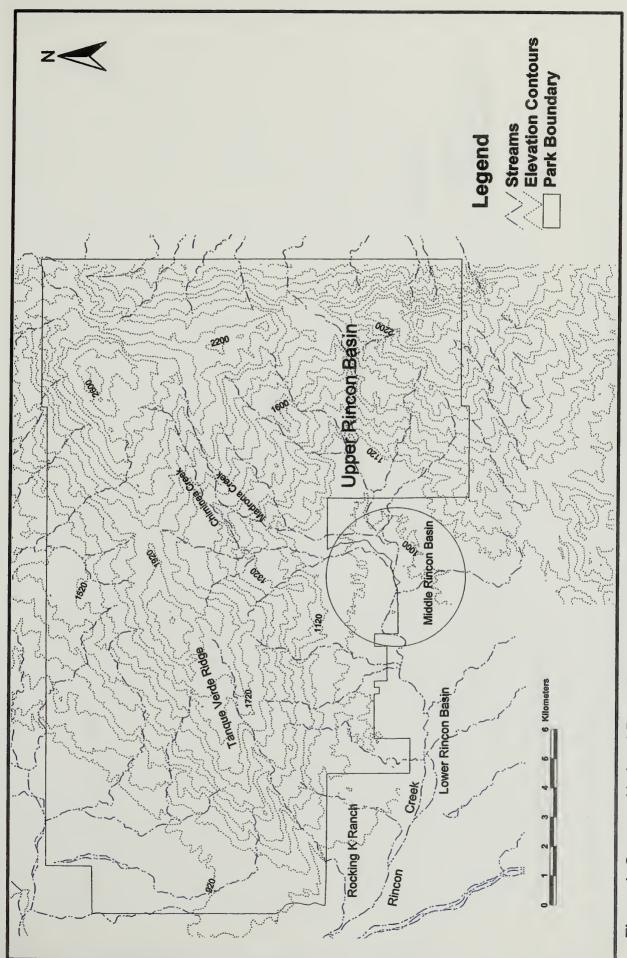


Figure 1. Saguaro National Park, East and associated portions of Rincon Creek.



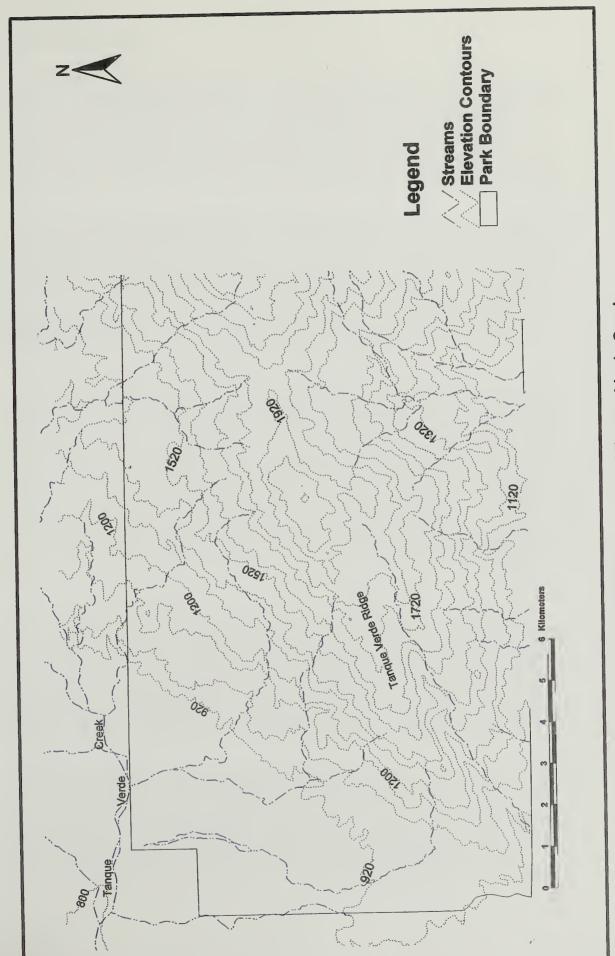


Figure 2. Saguaro National Park, East and associated portions of Tanque Verde Creek.



#### PROBLEM STATEMENT

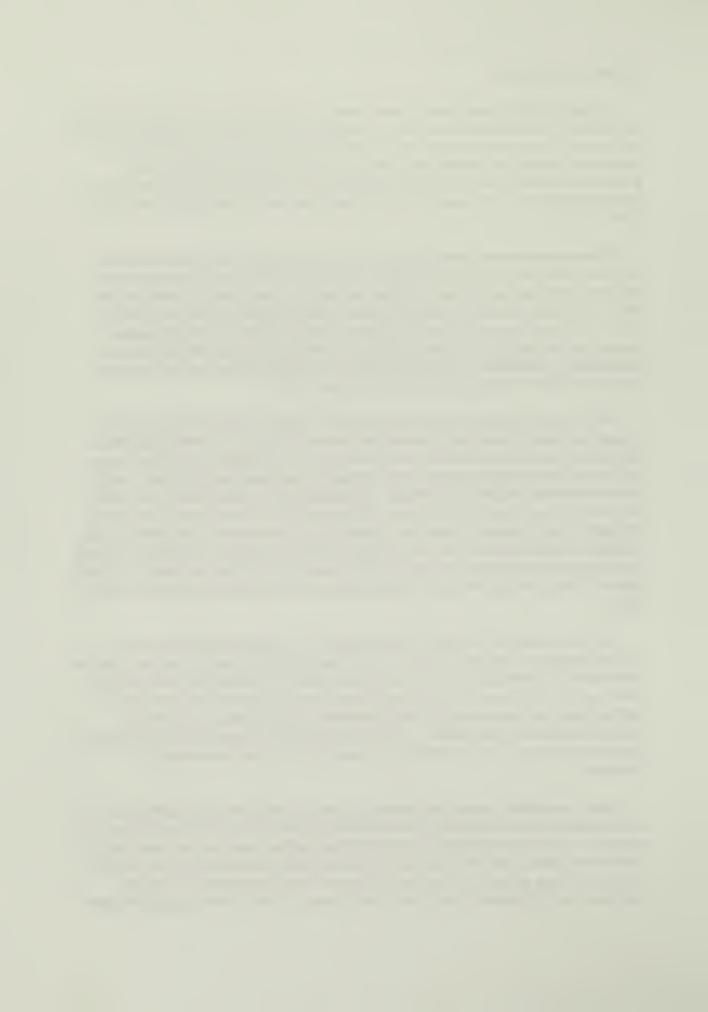
In Tucson's harsh, desert environment water is a critical resource within the Park and is essential to its biological communities. Springs, seeps, perennial and ephemeral stream reaches, and riparian areas sustain unique habitats important in maintaining the desert ecosystems the park was established to protect. Past land use activities, ongoing groundwater withdrawals, and continued growth in the Tucson area have created major changes in hydrologic processes and riparian landscapes within and adjacent to the park (Mott, 1997).

Historic accounts and records indicate that the hydrology of the Tucson area has changed significantly in the past 100 years. In the mid-1850's, mesquite trees covered the entire valley and cottonwoods, willows and walnuts grew along the major streams. Much of the area was marshy, making malaria a major problem (Smith, 1910; Arnold, 1940). The introduction of cattle, the cutting of trees for fuel and building materials coupled with a drought in the late 1800s lead to downcutting of stream channels and dewatering of streambeds. Wet marsh areas were replaced by deep arroyos that only occasionally filled with water (Hastings and Turner, 1962).

Water table declines have the potential to affect Saguaro National Park's resources through the loss of phreatophytic vegetation, decreased capacity of water supply wells, and fracture dewatering of bedrock with resulting loss of recharge to springs and seeps. The balance between groundwater levels, dependent vegetation, and associated wildlife can be particularly sensitive to alteration. Even small water table declines or increased fluctuation can negatively impact riparian habitats, which are not adapted to repeated or prolonged stress. Excessive extraction of near surface groundwater from areas adjacent to Saguaro National Park is a serious potential threat to the riparian resources of the park. Near boundary water extraction could result in water table declines that extend into park lands and impact vegetative communities dependent on near-surface groundwater (Mott, 1997).

The stream reaches in Saguaro National Park are best separated into one of two physical categories. The first category is comprised of high-gradient (>25m/km.) reaches characterized by alternating outcrops of bedrock channel with alluvial floored stretches. These pockets of alluvium occur upstream from geologic structures that create small, shallow basins that subsequently fill with sediments. All high-gradient reaches are described herein as "upper reaches". The second category is comprised of low-gradient reaches with slopes less than 25m/km. and characterized by continuous alluvial floodplains.

These low-gradient reaches are further described as middle or lower basin areas. The middle basin areas have relatively shallow alluvial sediments and occasional outcrops of bedrock or consolidated sediments, which form sub-surface dams. As the dams force the groundwater close to the stream surface, a shallow depth to groundwater is maintained upstream of these structures. The reach of Rincon Creek from one mile above its confluence with Chimenea Creek through the Expansion Area constitutes a middle basin



area. As is Tanque Verde Creek along the northern boundary of the Park, and the lower portion of one of it's tributaries lying within the boundary of the Park. Greater depths of alluvial deposits and generally deeper groundwater resources characterize the lower basin areas. The Tanque Verde lower basin area lies to the west of a point about two kilometers above its confluence with Aqua Caliente Wash and in the Rincon Creek basin the lower basin area lies to the west of Camino Loma Alta.

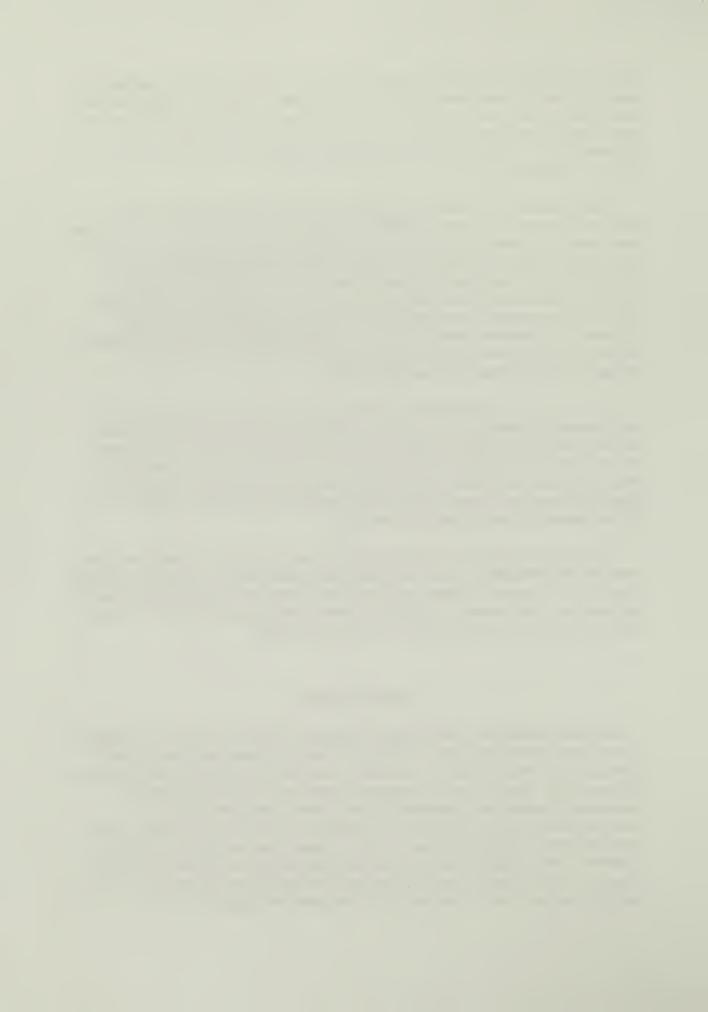
Specific threats to the riparian areas within the Park come from several sources: groundwater extraction from the middle basin areas and a change in land use in the upper basin areas. The middle and lower basin areas of Rincon Creek within the old Rocking K and to a lesser extent X9 Ranches are experiencing extensive urbanization (Figure 1). Rocking K Ranch development proposes a mixed-use, resort-oriented community to include residential areas, resorts and golf courses, and retail development (Briggs et al., 1996). Further upstream in the X9 Ranch area increased groundwater pumping for residential use outside the area is proposed. The magnitude of depletion and subsequent declines in riparian water tables are a clear threat to the continued existence of the riparian habitat along Rincon Creek (Mott, 1997).

Preservation of the riparian habitat within the park is becoming increasingly critical with the continued loss of riparian habitat in the Tucson basin. Not enough is known about the interactions between ongoing groundwater withdrawals, future developments, and the physical hydrology and biological processes active within the park's riparian areas. If a preservation scheme is successful it must include a means of quantifying and offsetting potential water level declines if these declines are determined to threaten riparian resources (Mac Nish and Guertin, 1997).

The goal of this study was to formulate recommendations for long term monitoring programs and strategies to protect the riparian areas within the Park. In order to achieve these goals, the present hydrology and flora of the riparian areas must be characterized and quantified. Information on the effects of antecedent stresses needs to be developed and the changes in hydrology, climate and land use quantified.

#### **METHODOLOGY**

Historical groundwater, well, geological and water resource information was gathered from various sources and analyzed. A literature search of Rincon and Tanque Verde Creeks, and the Tucson basin was conducted and pertinent information summarized (see literature cited). Initially, historical aerial photographs were located, assessed and electronically scanned (see Preliminary Product Review, June 1998 for list of photographs and sources). The scale of the photographs made their use impractical for study purposes. Numerous field surveys were conducted between September 1997 to December 1999 to document current vegetation and hydrologic conditions and assess potential problems. See Appendix A: Riparian Mapping, this report, for a more complete description of the vegetation mapping and current aerial photographic work.



#### **RESULTS: HYDROLOGY**

#### **TOPOGRAPHY**

North of Rincon Creek, including much of Saguaro National Park, the land rises steeply up to Tanque Verde Ridge in the Rincon Mountains. The land surface north of the creek is predominately rocky and rough. South of Rincon Creek the land rises more gently. The land south of the Creek is an alluvial plain whose surface slopes downward to the west in the southern portion of the plain and to the northwest closer to the apex of land lying between Rincon Creek and Pantano Wash. The inner valley surface is incised 12 meters or more below the level of the alluvial plain, with many small washes draining northward into Rincon Creek. Rincon Creek is an incision of the plain close to the northern edge where the alluvium laps upon bedrock of the Rincon Mountains.

#### GEOLOGIC STRUCTURE

#### Rincon Creek Basin

The Rincon Mountains are composed of metamorphic and intrusive igneous rocks and are the largest mass of low-porosity and low-permeability material bounding the Tucson basin. The least porous units are the least permeable and the most resistant; these rocks form the mountain range and the bottom of the sediment-filled basin and restrict the flow of groundwater into or out of the basin. These crystalline intrusive and metamorphic rocks contain water only where the rock is fractured and where rainfall or streamflow are sufficient and frequent enough to provide recharge. Many of the springs at the base of the Rincon Mountains are fed by rain and snow melt that are transmitted by fractures through the rocks and forced to the surface at the contact between the fractured crystalline rock and tightly cemented sedimentary rock down gradient of the spring. Springs in the higher parts are fed by water moving through fractures and the permanence and amount of their flow are dependent on the extent of the fractured system and on the frequency and amount of precipitation (Davidson, 1973).

The geologic framework of Tanque Verde Ridge and Rincon Valley including two major faults exerts strong control on the hydrology of the riparian systems within Saguaro National Park. Pantano Fault is a high angle fault running NNW just east of Pantano Wash (Figure 3). This fault constitutes a line of hydrogeologic separation between the occurrence and utilization of groundwater in the Rincon Valley and the main Tucson basin, and thus has a profound effect in isolating groundwater in the lower basin of Rincon Creek from the effects of pumping in the Tucson basin.

The gently dipping Catalina thrust fault outcrops along the base of the mountain flanks on both sides of Rincon Creek (Figure 3). This fault, formed in late Cretaceous time, may have been reactivated as a glide fault in Miocene time as the crystalline cores



of the ridges flanking the Rincon Creek trough rose and the upper plate of the thrust faults slid into the synclinal (downfolded) trough (Thorman and Drewes, 1981). Thorman and Drewes (1981) describe disharmonic faults associated with the thrusts that butt into the thrust from above but do not cross the thrust plane. They hypothesize that these disharmonic faults were formed during thrusting to relieve stresses building up in the upper plate as the thrust faulting moved the upper plate over a gently undulating plane. They also describe the glide faults as both independent structures, and as reactivation of the earlier thrust faults.

Thorman and Drewes (1981) did not map the Rincon Creek area in as much detail as they did mineralized areas. However, their descriptions suggest that either disharmonic faults reactivated during the glide faulting, or imbricate glide faults branched off the Catalina fault when it was reactivated creating a series of small structural basins. These basins extend from the point where the outcrop of the Catalina fault crosses Rincon Creek to Sentinel Butte. Such structures may extend westward beyond Sentinel Butte, but the unconsolidated alluvium deepens to the west and we found no visual evidence to suggest their existence. A hypothetical cross-section of the nature of the structures creating the small structural basins is illustrated in Figure 4. While no attempt was made to map faults during this study, the alternation of bedrock outcrops in the channel of Rincon Creek with alluvial floored channel segments is consistent with the presence of such structures. These features are observed in the middle basin area as far west as Sentinel Butte.

Faults of small displacement along the flanks of the Tanque Verde Ridge anticline, and the alternation of competent layers with less competent layers combine to form a series of basins in some of the tributaries to Tanque Verde and Rincon Creeks. The larger and usually deeper basins have filled with alluvium deposited by the stream and retain shallow groundwater. In many instances the groundwater system in these basins is probably replenished by streamflow resulting from storms in the drainage basin or springs/seeps caused by the same structure that formed the small basin, and not from the regional groundwater system.

In the alternating bedrock and alluvial sediment within the Expansion Area of Rincon Creek channel, groundwater moving down and to the west through the alluvial material is forced to the surface by a series of partially buried bedrock "dams". After crossing such features the stream flows back into the alluvium until it reaches the next downstream barrier. During times of high groundwater flow, as in the spring, stream flow is continuous through this reach, but by early summer, the flow occurs intermittently in the reaches immediately upstream from the bedrock "dams" (Figure 4). The limited data available suggest that the regional groundwater system is in hydraulic connection with the groundwater in the alluvium of the middle basin area of Rincon Creek. Additionally, withdrawals from the Rincon Water Company well would quickly drain the small alluvial aquifer during the dry months of each year unless the alluvium was also receiving recharge from the regional groundwater system (see Historical Well Data, this report).



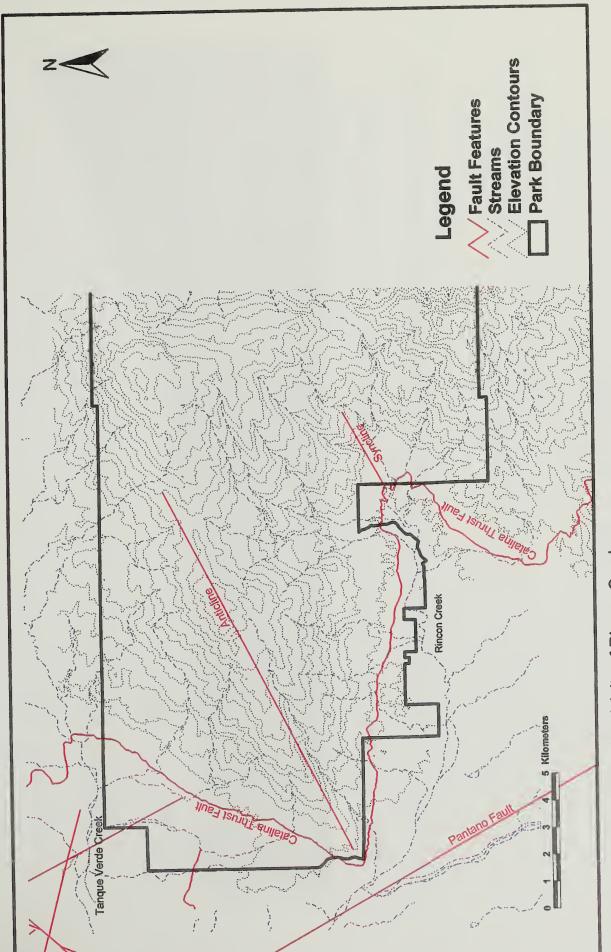


Figure 3. Major Faults in the vicinity of Rincon Creek.



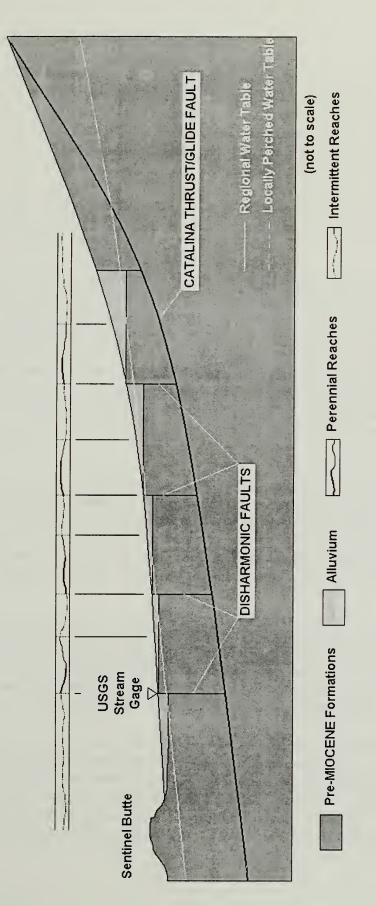


Figure 4. Schematic Cross-section along the axis of the Rincon Valley syncline from Sentinel Butte to the outcrop of the Catalina Fault.



### Tucson Basin and Tanque Verde Creek

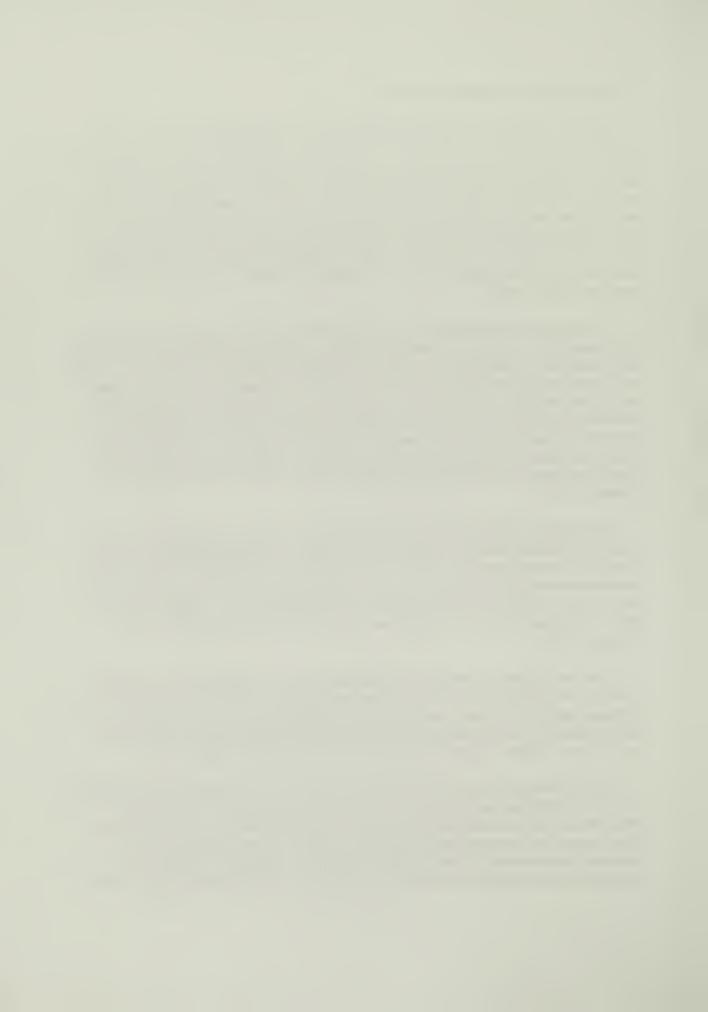
Southern Arizona lies within the Basin and Range physiographic province. Fine sediments from adjacent highlands were deposited in a relatively low-grade environment during the Eocene and early Oligocene. Although the source areas have mostly eroded away, a major portion of these Tertiary sediments crops out in the Tucson area. The geology of the Tucson basin was influenced by two major Tertiary tectonic events: the mid-Tertiary orogeny and the Basin and Range disturbance. Volcanism, metamorphism, listric faulting and uplift characterized the mid-Tertiary orogeny and contributed in part to the uplift of the Catalina highlands. Sediments derived from mid-Tertiary volcanism and uplift are typically thick sequences of conglomerates, fluvial overbank, and lacustrine deposits (Rogers, 1987).

The Basin and Range disturbance was the most recent major tectonic event to affect the Tucson basin. During this time, block faulting produced subsiding basins into which large volumes of sediments were deposited. This block faulting erased previous drainage and depositional patterns and created the typical horst and graben terrain that is present today. By the middle of the Miocene, the cover of mainly volcanic flows and related sediments had been removed from the Catalina highlands exposing the gneissic core. As faulting continued, increasing percentages of gneissic material were deposited. By the close of the Basin and Range disturbance, depositional sediments in the northern and eastern portions of the Tucson basin contained well over 90 percent Catalina gneiss (Rogers, 1987).

Two episodes of Basin and Range block faulting have been recognized. The main episode of faulting resulted in the formation of a deep north-south trending structural trough and deposition of thousands of feet of sediments and evaporites. Vertical fault movement exceeded depositional rates and closed basins evolved resulting in lacustrine and/or playa conditions in the basin interior in the middle Miocene. Development of exterior drainage systems terminated these southern Arizona lacustrine conditions (Rogers, 1987).

In the late Miocene, a second episode of faulting with renewed uplift of the Santa Catalina, Tanque Verde, and Rincon Mountains occurred. This resulted in the formation of shallow structural troughs imprinted upon the older structures. Basin and Range faulting gradually declined during the early Pliocene and had essentially ceased by the late Pliocene. General tectonic quiescence has since prevailed (Rogers, 1987).

Along the basin margins and mountain fronts extensive pedimentation and truncation of the older deformed sediments followed the end of the faulting. A well-defined pediment surface was formed extending from the Santa Catalina and Rincon Mountain fronts toward the interior of the Tucson basin. Cutting into the deformed Tertiary sediments, this erosional surface formed the base upon which the undeformed and unconsolidated late Pliocene and Pleistocene sediments were deposited (Rogers, 1987).



Basin filling continued well after the Basin and Range block faulting had ceased. By the late Pleistocene, maximum filling of the Tucson basin occurred with the deposition of the Fort Lowell Formation. Sediments of this formation were deposited mainly as a result of climatic effects. Along the basin margins, subsequent episodes of erosion and stream downcutting have stripped away much of the late Pliocene and Pleistocene sediments and exposed older sedimentary units (Rogers, 1987).

Surficial deposits in the northeast area of the Tucson basin consist mainly of Pleistocene and Holocene terrace deposits and localized Holocene stream and flood plain deposits. Characterized by a high degree of weathering, the terrace deposits average ten meters in thickness. Stream deposits consist of loose silty gravelly sand to coarse sandy gravel and the flood plain deposits are typically a loose silt or silty sand. Stream and flood plain deposits occur within and adjacent to the streambeds of Agua Caliente, Pantano, Ventana Canyon, and Rillito washes and Sabino and Tanque Verde creeks. The stream and flood plain deposits adjacent to Tanque Verde streambeds are derived mostly from Catalina Gneiss since it drains primarily from the Santa Catalina and Rincon Mountains (Rogers, 1987).

The hydrogeology of Tanque Verde Creek changes near the confluence with Agua Caliente Wash. Below Agua Caliente Wash is a structural trough of thick, unconsolidated, highly permeable Pliocene and Pleistocene sediments which overlie the older consolidated Miocene and Oligocene rocks. About two kilometers above the confluence, faulting and subsequent erosion have resulted in relatively shallow depth of the older, lower permeability, consolidated sedimentary Miocene and Oligocene rocks. Because of the greater hydraulic conductance and thickness of the younger unconsolidated sediments, the downstream section has been more intensively developed by Tucson Water as a source of high quality, low cost groundwater. (Stromberg et al., 1992)

#### WATER RESOURCES

There are two contributing sources of water to the Rincon Creek basin. One is mountain front recharge and the other is runoff in Rincon Creek. Groundwater contour maps of the area indicate that the direction of groundwater flow is from northeast to southwest (Osterkamp, 1973). The reach of Rincon Creek in the lower basin area downstream from the expansion area of the park is a line source of groundwater recharge where storm run-off infiltrates into the alluvium and percolates downward to the water table. On an average annual basis the flux through Rincon Valley was estimated to be 4,540 acre-feet per year (5.6 Mm³). Consisting of 3,500 acre-feet (4.3 Mm³) as recharge from runoff in Rincon Creek and 1,040 acre-feet per year (afy) (1.3 Mm³) from mountain front recharge (Osterkamp, 1973). Burkham (1970) found that the infiltration along Rincon Creek from the gauging station to Camino Loma Alta was relatively low but from there to Old Spanish Trails crossing the rate was extremely high. These rates correlate with the geology of Rincon Valley.



Davidson (1973) estimated that only about 3,000 acre-feet (3.7 Mm³) per year moved as groundwater into the Tucson basin along a 16 km band that crossed the mouths of Rincon Creek and Pantano Wash. United States Geological Survey (USGS) streamflow data indicate that Pantano Wash delivers almost twice the annual flow of Rincon Creek. If one assumes that the amount of groundwater moving in the alluvium of these two streams is in similar proportion and that only a small amount moves in from the adjacent ridges, one might estimate that the groundwater discharge is about 1.1 Mm³ /y and 2.0 Mm³ /y from Rincon Valley and Pantano Valley, respectively. The amount of groundwater discharge at the park's western boundary would be smaller, as the area that Davidson's estimate was for 6.5 km to the west. Using the drainage area above the park's western boundary (in the Rincon Valley alluvium) and the drainage area in Rincon Valley above Davidson's line, one could estimate 85% of the 1.1 Mm³ or 0.94 Mm³ /y crosses the park's western boundary.

### HISTORIC WATER DEMAND

Until about 1980, much of the land along Rincon Creek was irrigated to produce feed for livestock. Historic water demand for uses other than irrigation was minimal. According to the Arizona Corporation Commission (ACC) the following three water companies produced a total of 27.48 acre-feet (33,900 m³) in 1984: Loma Alta, Rincon Creek and Thunderhead. The total private residential pumpage was only about 2.4 acre-feet per year (2,960 m³/y). The larger Ranchland Water Company produced 39 acre-feet (48,100 m³) of groundwater for use by 257 local residents for a total of 135 gallons (511 liters) per capita per day. Downstream use by Ranchland Water Company required that additional 46 acre-feet (56,700 m³) per year be taken directly from Rincon Creek. Of these four water companies, only Rincon Creek extracted water from within the current study area. Ranchland Water Company occupied the area now known as Rocking K Ranch and utilized water resources further west and downstream (Halpenny and Halpenny, 1985).

The Rincon Creek Water Company service area occupies 437 hectares of mostly very rough terrain underlain by Precambrian and Mesozoic rock. It draws water from wells in the middle basin area upstream of the current United States Geological Survey gauging station on Rincon Creek and several miles upstream from the Precambrian and Mesozoic rock outcrops that separate Tucson basin from "Rincon" basin. This area is within the Park's expansion area and includes the best remaining and most threatened riparian habitat along Rincon Creek. Specific historic pumpage values for Rincon Creek water company were not available; however, in 1984 it only served one customer (Halpenny and Halpenny, 1985).

### **PRECIPITATION**

Precipitation drives the hydrologic system in the Rincon Creek basin. There are no other inputs of groundwater for this basin (both mountain front recharge and creek infiltration start as precipitation). The thickness of the saturated alluvium varies, but the

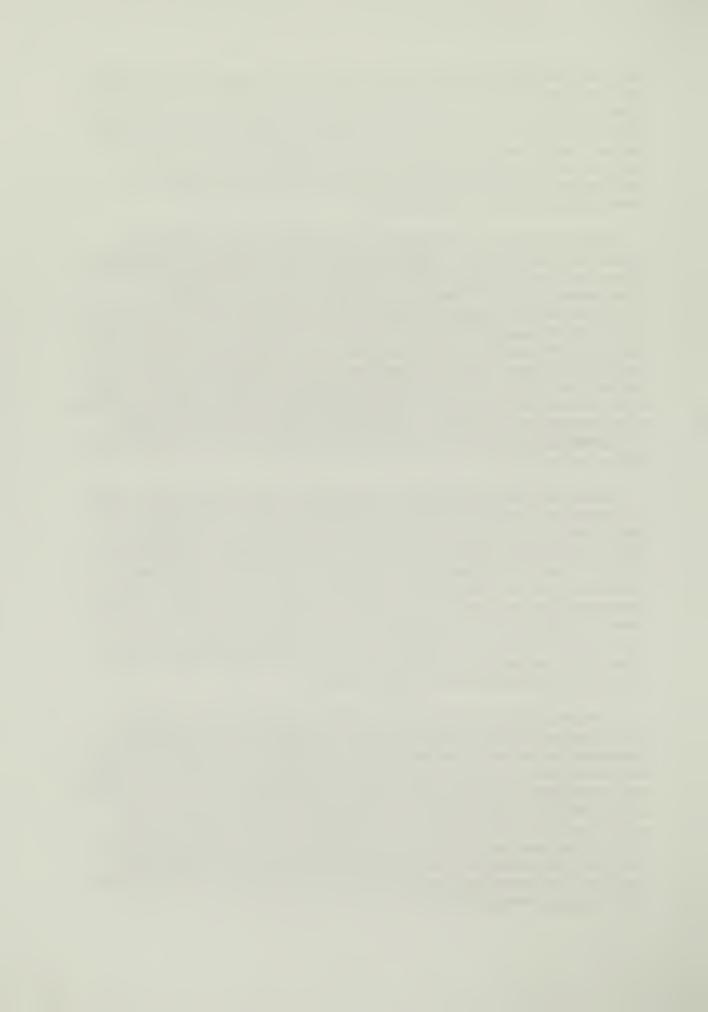


overall storage capacity is orders of magnitude less than the saturated sediments within the Tucson basin (Mott, 1997). Since the depth of alluvial material is not extensive in the middle basin, this area has minimal water storage capacity. Precipitation also drives the hydrologic conditions of the Tanque Verde tributaries. Most of the tributaries are high-gradient washes typical of upper basin areas, with limited if any storage capacity. As with most washes in arid and semi-arid areas, these washes run only in response to rainfall events. This makes the amount and timing of available precipitation and its balance with groundwater extraction critical.

Ideally one would compare long-term basin precipitation data, streamflow and measured groundwater levels. Unfortunately, there is no weather station within Saguaro National Park, east. Precipitation data was collected from Tucson Magnetic Observatory (TMO) located at Tanque Verde Road and Sabino Canyon and at Santa Rita Experimental Range. Appendix B contains a complete list of monthly and annual rainfall amounts for both stations. The Tucson Magnetic Observatory is the closest measurement location and was considered an appropriate data source. Total annual rainfall for TMO was plotted in Figure 5. While not a long-term trend, there appear to be more wet years after 1977 than from 1934 to 1977. If anthropogenic factors weren't present one would expect to see a subtle increase in recruitment and improved riparian conditions as a result of the increased water availability. Yet all available information (literature and field observations) indicate a decrease in riparian plant recruitment and a decline in the overall health of the community.

To get a rough idea of how Rincon Creek responds to precipitation events, monthly precipitation measured at the observatory was graphed against monthly stream flow on Rincon Creek. Several assumptions are inherent in this comparison. The first is that rainfall at TMO reflects conditions on the Rincon Creek watershed. In the winter with the large, slower moving frontal storms common to the Tucson area this isn't a bad assumption. However, summer precipitation falls as a result of very localized convective thunderstorms and conditions can vary greatly from one location to the next. Figure 6 shows three relatively wet years while Figure 7 reflects three drier years. None of these years represent extreme years. In both cases, there is a general pattern of increasing stream flow in response to increased precipitation. Note that on both figures streamflow is calculated on a log-scale that accentuates low flows.

As reported by Halpenny and Halpenny (1985) groundwater levels, especially in areas of shallow alluvium, are tightly coupled to precipitation. From the perspective of keeping the riparian communities intact, water table levels must stay within the rooting zone of the riparian vegetation the majority of time from March to October. The winter rains are critical in recharging the groundwater in the middle basin areas of Tanque Verde and Rincon Creeks, while summer rains help maintain the high-gradient upper basin areas and replenish the soil moisture in the middle basin areas. The small riparian pockets in the upper basin areas have extremely limited water storage capacity and are much more sensitive to short term fluctuations in weather conditions. Groundwater extractions in the middle basin areas must be balanced by recharge on a seasonal basis to keep the riparian communities intact.



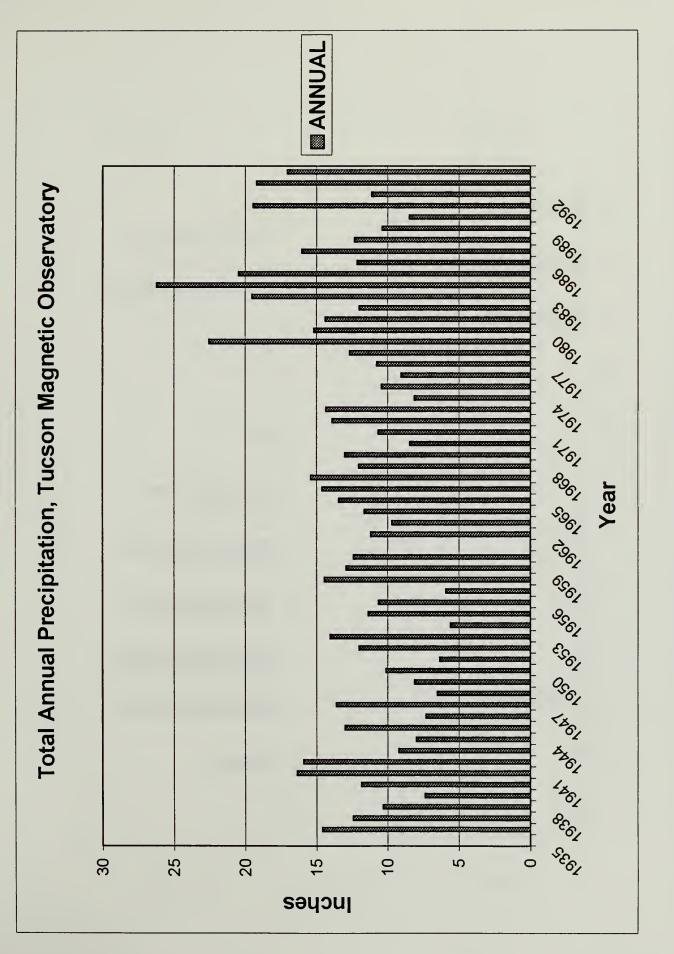
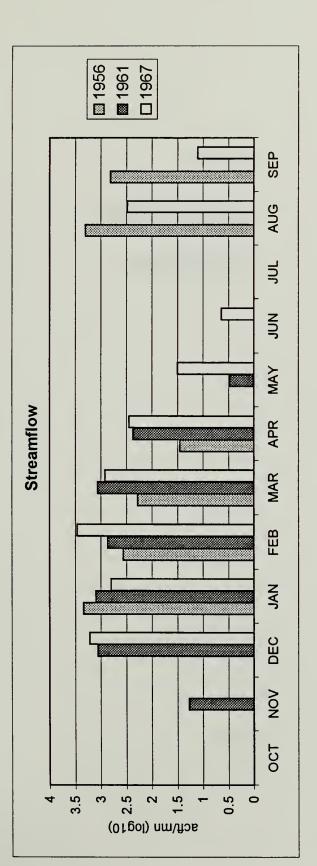


Figure 5. Total annual precipitation in inches, Tucson Magnetic Observatory (1935-1993)





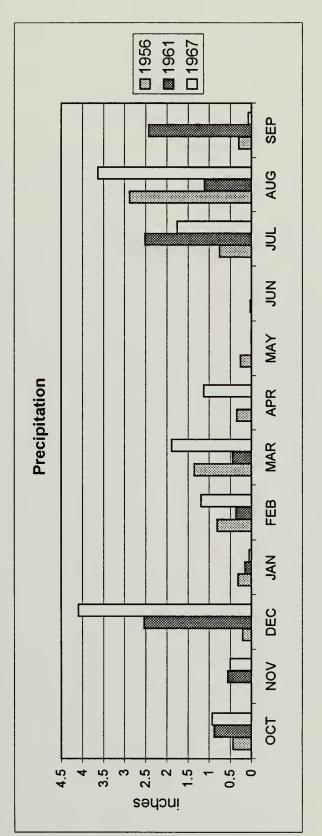


Figure 6. Total monthly precipitation at TMO (top) and total monthly streamflows (acre feet month) Rincon Creek. Data from three relatively wet years.



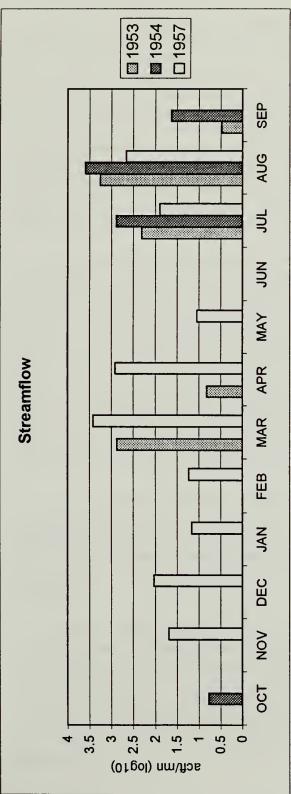


Figure 7. Total monthly precipitation at TMO (top) and total monthly streamflows (acre feet month) Rincon Creek. Data from three relatively dry years.



## **Rincon Creek Gauging Station**

The USGS began operating a gauging station (USGS station number 09485000) on Rincon Creek approximately 300 to 400 meters upstream of Sentinel Butte on October 1, 1952. Through September 30, 1974, the station was operated as a total station measuring total annual runoff and discharge peaks. From October 1, 1974 to Sept 1989 the station was operated as only a crest-stage partial record station. In September of 1989 it was converted back to a total station and has continued as such to present day. Halpenny and Halpenny (1985) reported that the highest peak discharge during the first 32 years of record was 9,660 cubic feet per second (cfs) (274 m³/s) on August 19, 1971. Peak flows through 1994 are illustrated in Figure 8. USGS has not released more current data. The peak flow of 274 m³/s still remains the historic peak discharge. A record of USGS historic peak flows for Rincon Creek through 1994 is listed in table 1. No trend or change in peak flows is apparent from these data.

Total annual and average daily flows were calculated for all available years through 1996 (Table 2). Flows for 1974 through 1988 were not measured and therefore not available. The wettest year recorded was 1992 with total annual flow of 29.8 Mm³ per year (24,172 afy) and a calculated average daily flow of 81,500 m³/day (66.04 acrefeet/day). This is considerably higher than the remaining wet years: 1965, 1972, and 1994, which averaged 59,400, 40,200 and 52,200 m³/day respectively. 1955 has the dubious distinction of being the driest year with a total annual flow of only 64,100 m³ (51.97 afy) or averaging only 173 m³/day. Out of the 30 years of data available, four years had average daily flows of less than 1233 m³/day (1 acre-foot/day): 1955, 1966, 1973, and 1995. Three of those years had total annual flows of less than 123,300 m³ per year (100 afy). Total annual streamflows are illustrated in Figure 9. Indicative of a semi-arid climate there are considerably more dry years than wet years.

Due to the skewed distribution of flows and the high number of no-flow days, it is often more telling to look at the standard deviation around the mean flow. Figure 10 graphically illustrates the wide fluctuations calculated for each mean. The fact that Rincon Creek has years where the calculated average daily flow equaled or exceeded the total annual flow of other years speaks to the extreme variability in hydrologic conditions.

Variable annual streamflow is not the only problem facing riparian communities in the arid southwest. Timing of the streamflow and water availability is critical. Tucson has a bimodal precipitation distribution resulting in the same bimodal distribution in stream flow. Figures 11 through 13 show the monthly streamflow for the 1950s, 1960-1973 and 1989-1996 respectively. Monthly totals vary from year to year but a pattern of wet winters and potentially high flows in the late summer months due to the monsoons is clear. Appendix C contains a complete list of monthly streamflow data for Rincon Creek gauging station.



Figure 8. Historic peak streamflows (cubic ft./sec), Rincon Creek.

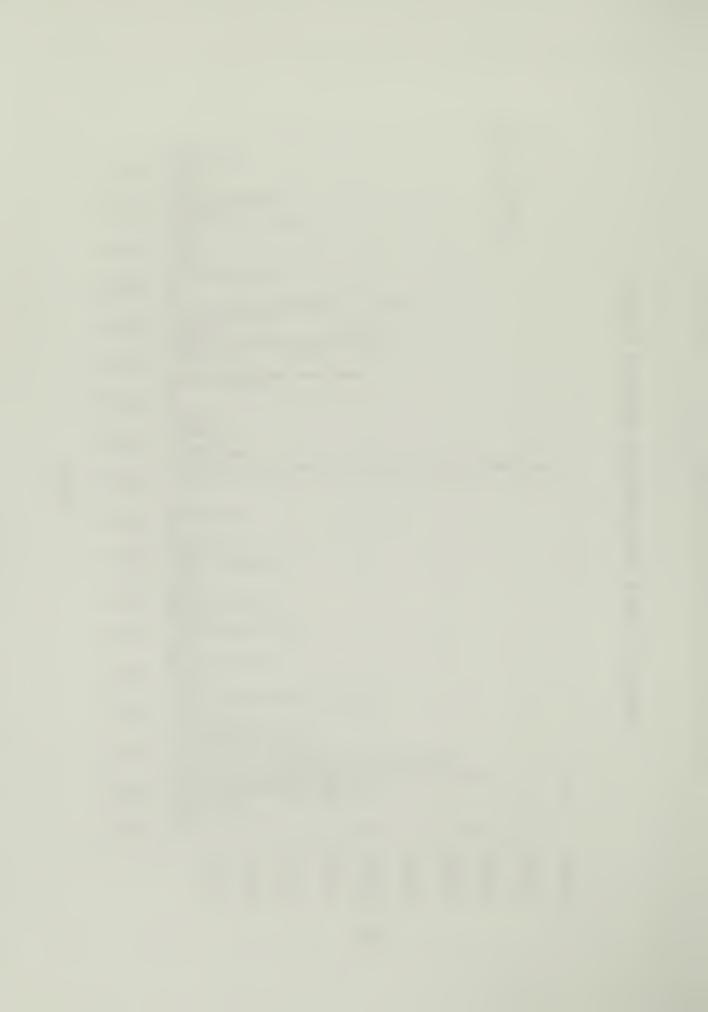


Table 1. Peak streamflows (cubic feet/second) Rincon Creek, Tucson Arizona.

Year	Month	Discharge (cfs)	Year	Month	Discharge (cfs)	Year	Month	Discharge (cfs)
1953	7	194	1963	80	323	1981	80	236
1954	က	640	1963	6	409	1982	∞	1800
1954	7	525	1964	6	948	1983	_	688
1954	œ	2160	1964	တ	433	1983	9	5640
1954	œ	550	1965	ω	311	1985	_	647
1955	7	1000	1965	12	3100	1986	7	1170
1955	7	5050	1965	12	2210	1986	12	535
1955	7	4070	1965	12	586	1988	∞	2640
1955	œ	8250	1965	12	1300	1989	7	88
1955	œ	312	1966	œ	379	1990	7	6320
1955	<b>∞</b>	7170	1966	တ	550	1990	7	558
1955	œ	682	1967	œ	157	1990	7	343
1955	œ	4030	1967	12	1650	1990	7	514
1956	7	150	1968	7	1860	1990	7	381
1957	-	3570	1968	∞	930	1990	∞	2940
1957	∞	1990	1969	_	323	1991	-	692
1957	∞	2440	1969	റ	548	1991	က	1180
1957	∞	1850	1970	7	448	1991	12	536
1958	က	492	1970	∞	1200	1992	7	871
1958	∞	447	1970	တ	1040	1992	∞	455
1958	9	5220	1971	∞	0996	1992	12	642
1959	∞	580	1971	∞	410	1992	12	964
1959	∞	357	1971	∞	1960	1993	_	3720
1959	∞	415	1971	တ	1420	1993	_	731
1959	∞	1240	1972	7	360	1993	_	1120
1960	_	747	1972	9	1440	1993	_	2890
1961	∞	2600	1973	7	1360.	1993	∞	2810
1961	∞	325	1973	7	1430	1994	က	237
1961	တ	430	1973	က	406			
1962	_	227	1974	∞	664			
1963	7	454	1975	တ	340			
1963	∞	3420	1977		230			
1963	œ	837	1977	_	127			
1963	∞	1240	1978	_	2440			
1963	∞	713	1978	12	4890			
1963	œ	2810	1980	2	586			

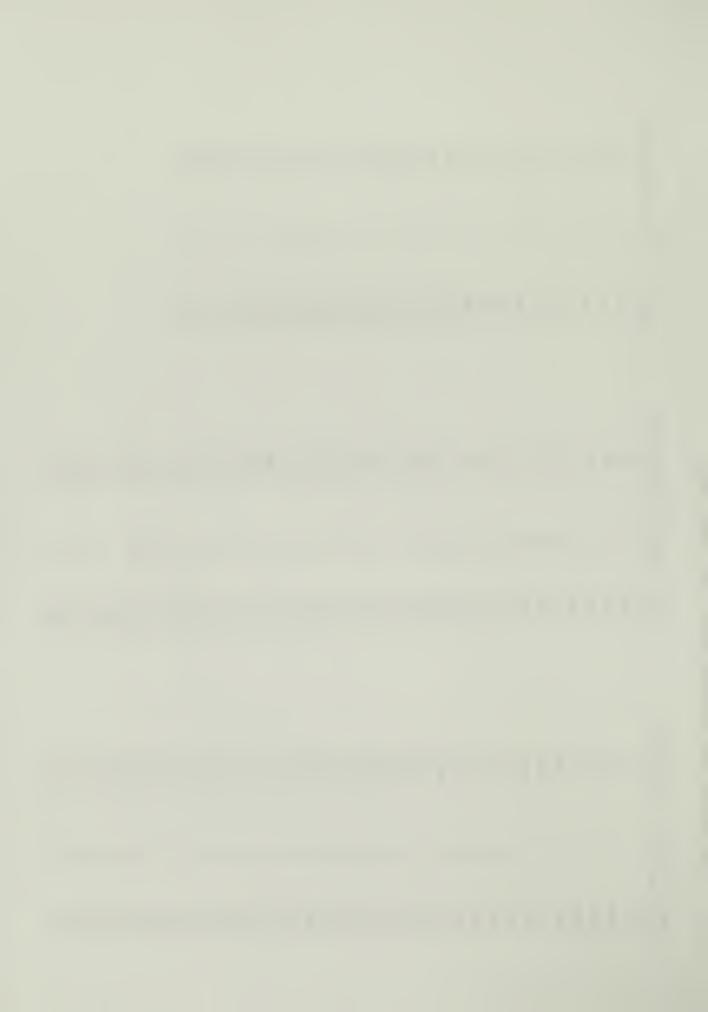


Table 2. Total, average, standard deviation and variance of annual streamflow, Rincon Creek gaging station.

	k gaging station.	A	Otal alass	Variance
Year		Average (acft/day)	Std dev	Variance
1952	591.68	1.62	7.55	56.97
1953	2764.21	7.55	52.37	2742.13
1954	4756.63	13.00	64.92	4214.55
1955	51.97	0.14	0.85	0.73
1956	5406.43	14.77	90.52	8194.04
1957	4160.99	11.37	37.76	1425.92
1958	2227.27	6.09	32.15	1033.80
1959	5680.35	15.52	46.08	2123.46
1960	764.04	2.09	16.37	267.90
1961	4533.69	12.42	24.28	589.62
1962	4366.68	11.96	44.55	1984.48
1963	1238.89	3.38	18.72	350.41
1964	965.37	2.64	5.21	27.13
1965	17589.88	48.19	145.29	21108.42
1966	72.60	0.20	1.43	2.04
1967	6595.69	18.02	88.29	7794.82
1968	988.16	2.71	9.84	96.89
1969	1602.85	4.39	33.18	1101.22
1970	2976.24	8.13	72.35	5234.56
1971	2599.22	7.10	17.95	322.13
1972	11934.44	32.61	128.65	16551.68
1973	279.32	0.76	6.77	45.86
1989	3131.05	8.55	40.90	1672.69
1990	7816.68	21.36	61.91	3832.37
1991	8592.88	23.48	60.81	3697.30
1992	24171.94	66.04	252.08	63542.92
1993	949.54	2.59	14.29	204.07
1994	15477.75	42.29	154.97	24015.60
1995	68.89	0.19	1.79	3.22
1996	551.85	1.51	6.74	45.44



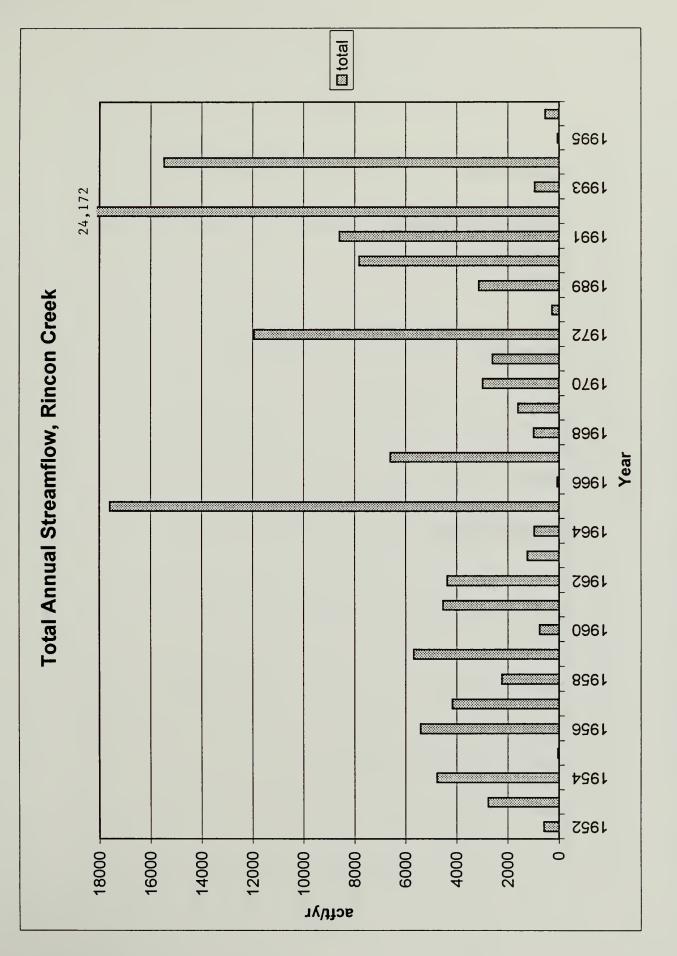
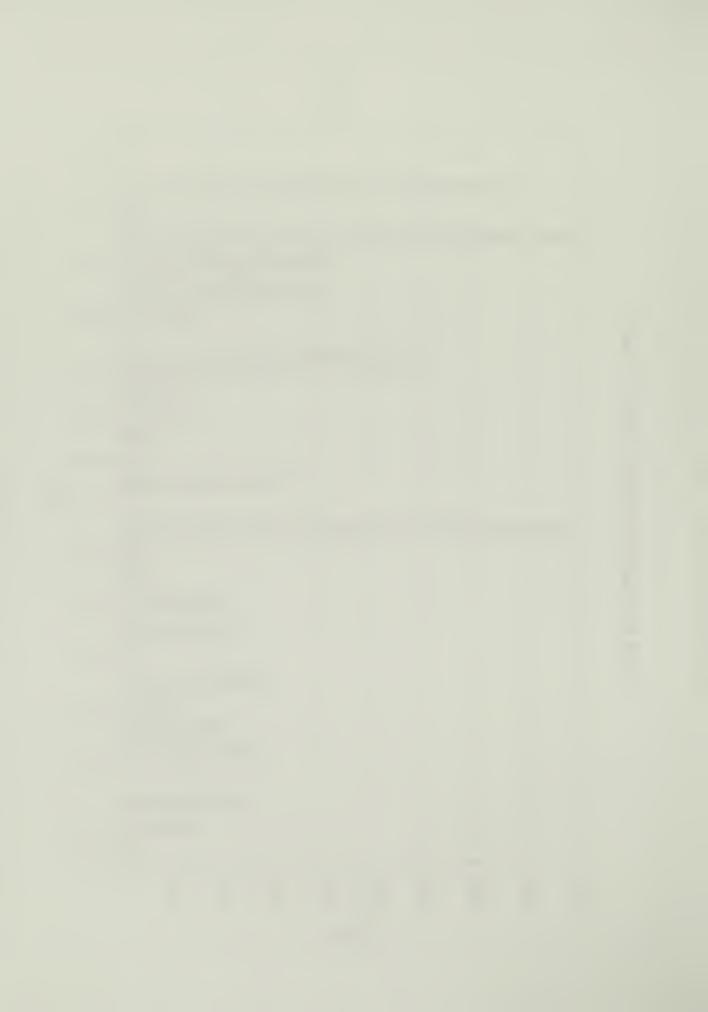


Figure 9. Total annual streamflow (acre-feet/year) for years 1952-1973 and 1989-1996, Rincon Creek.



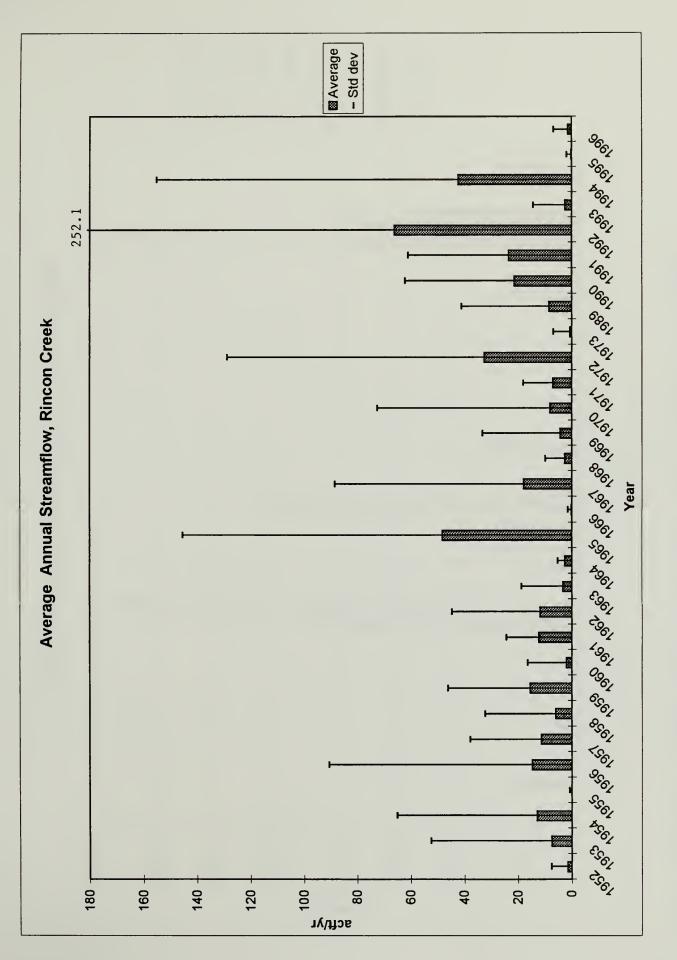


Figure 10. Average annual streamflow plus one standard deviation (acre ft/year), Rincon Creek.



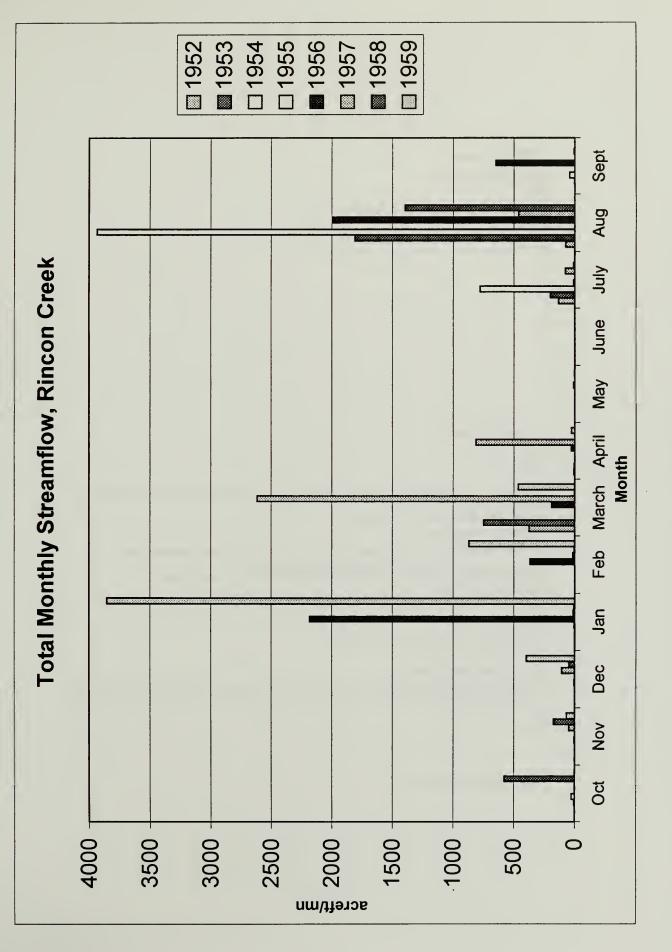
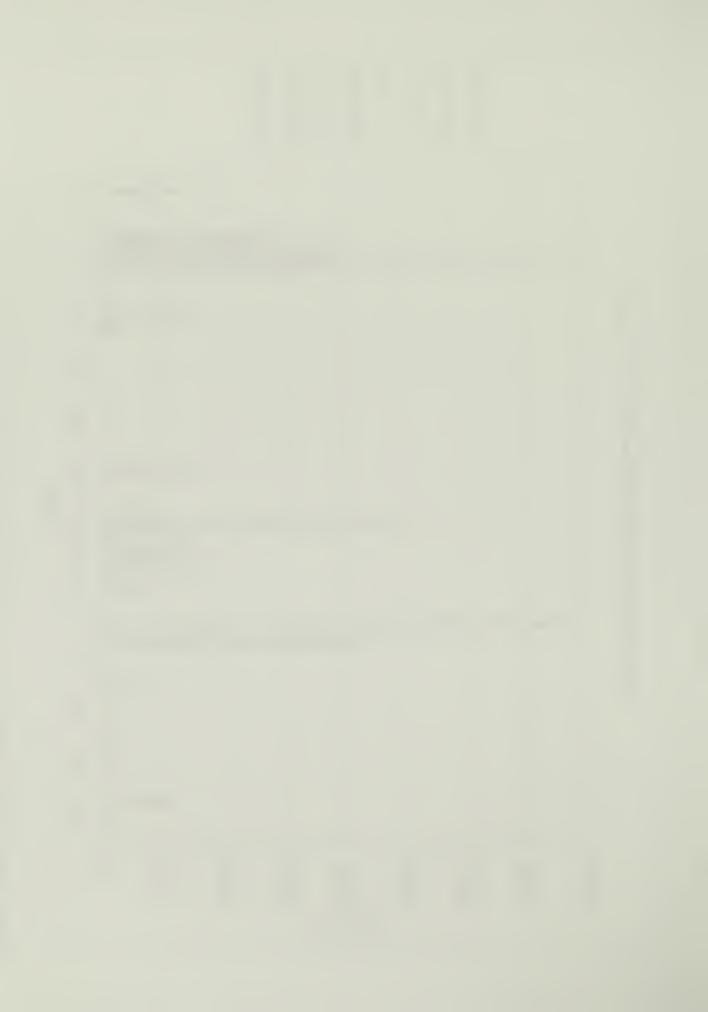


Figure 11. Total monthly streamflow (acre ft/mn) calculated from average daily cfs, Rincon Creek (1950s).



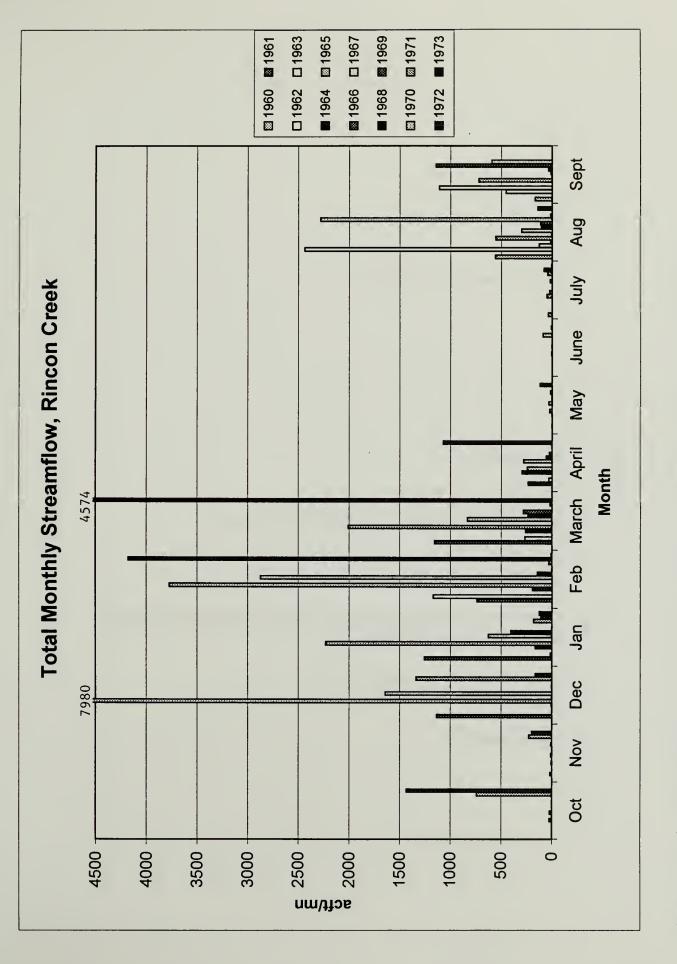


Figure 12. Total monthly streamflow (acre ft/mn) calculated from average daily cfs, Rincon Creek (1960-1973).



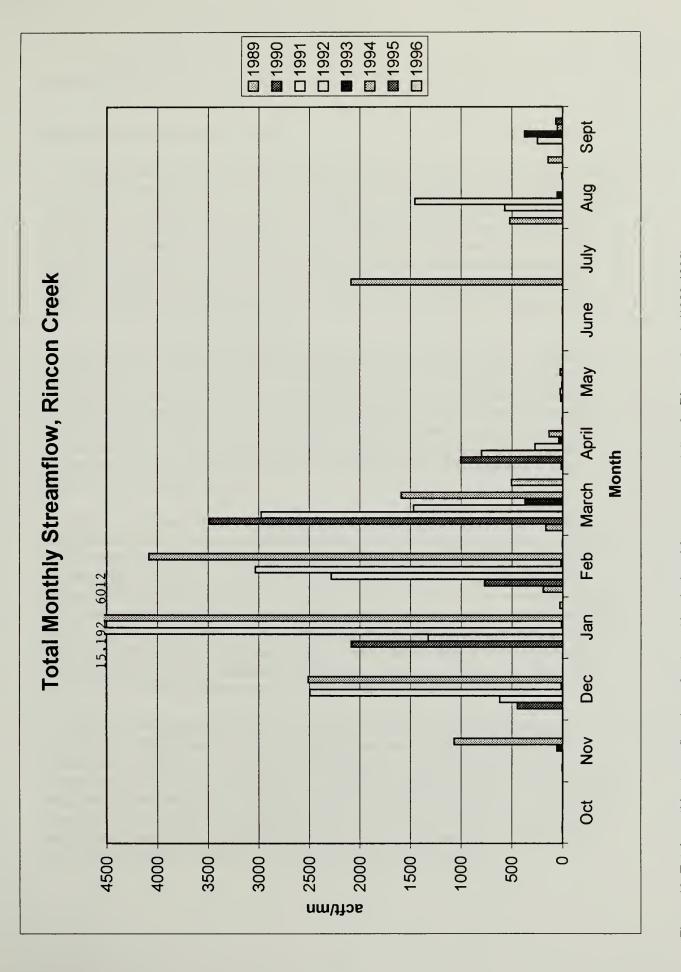
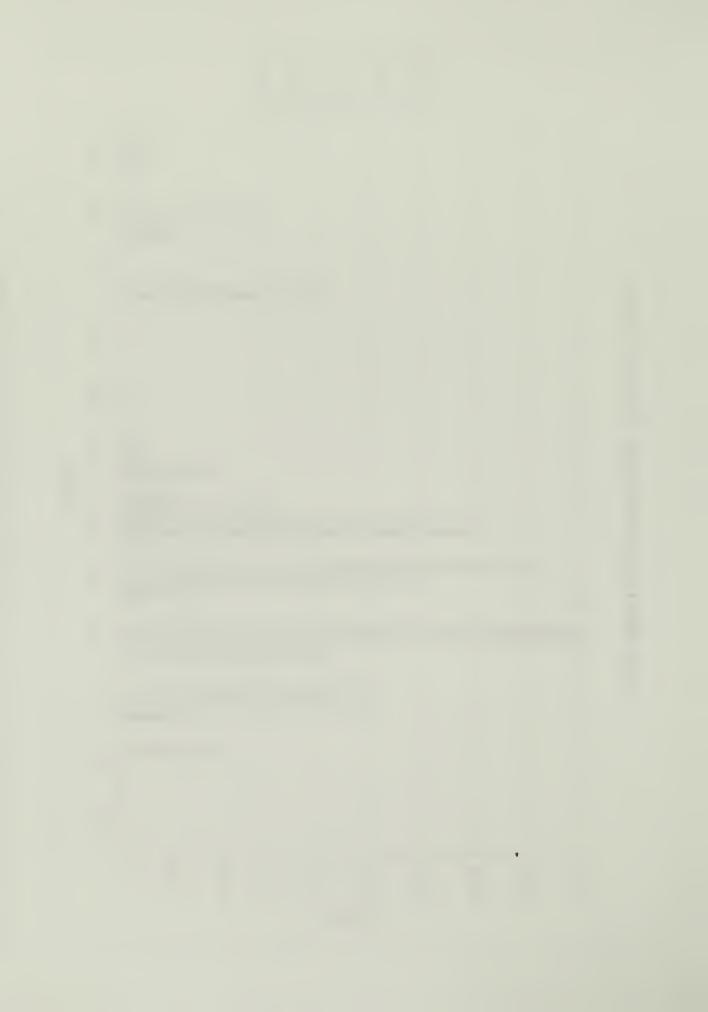


Figure 13. Total monthly streamflow (acre feet/month) calculated from average daily cfs, Rincon Creek (1989-1996).



#### HISTORIC WELL DATA

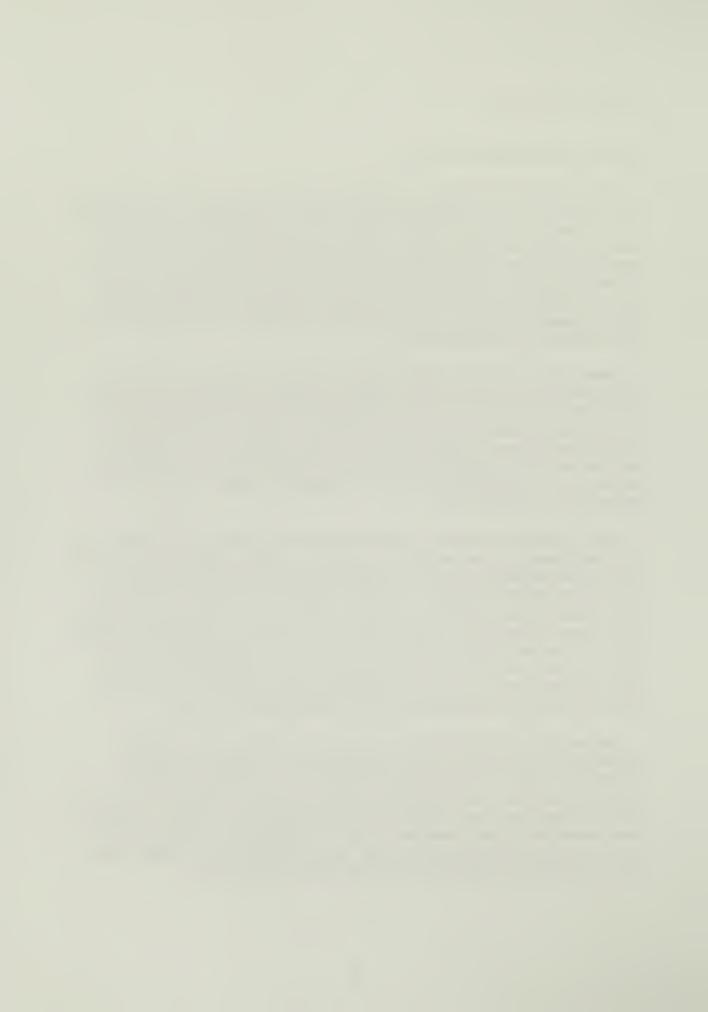
# Rincon Creek Middle Basin Aquifer

The direction of groundwater movement in the area is predominantly southwestward from Rincon Creek across the Pantano Fault and into the Tucson basin. The groundwater reservoirs supporting the riparian areas within Rincon Mountain District are not directly connected to the Tucson basin aquifer. This is critical since drawdown within Tucson basin is, in most areas, already sufficient to place the water table well beyond the depth of the riparian vegetation. The majority of Rincon Creek flow infiltrates into the ground before reaching the confluence with Pantano Wash. While flows in Pantano Wash are readily recharged, this recharge does not contribute to the groundwater supply of Rincon Valley (Halpenny and Halpenny, 1985).

Water levels in the Rincon Valley have been recorded as early as 1941. Halpenny and Halpenny (1985) using what they considered a plethora of data gathered from 1947-1980 found that the water level in 1980 was slightly lower than when first measured. However, they concluded that the data indicated a general pattern of decline during the dry periods and an increase during wet times. They concluded that the aquifer system was effectively in balance between long-term recharge and long-term natural discharge plus historic (1950 to 1980) withdrawals. Unfortunately, conditions appear to have declined in the succeeding years.

While groundwater levels still respond to both seasonal and long-term fluctuations in precipitation patterns, numerous indicators point to an overall lowering of the water table in both the middle and lower basins. The riparian corridor between the X9 Ranch and Sentinel Butte (within and adjacent to the Park expansion area) contains remnants of a once much larger and more lush riparian forest. Areas once covered by mesquite bosque are now home to desert scrub. The surviving riparian trees line the immediate creek bank and in many cases show signs of long-term water stress. Personal observation and the results of an earlier study conducted by the Rincon Institute suggest that groundwater drops off steeply west of Sentinel Butte. Depth to water approximately 3.2 km down stream was reported at eight meters below the surface (Briggs et al., 1996).

Well data was collected for the entire Saguaro National Park area including the following six USGS township (T) and range (R) parcels: T14SR16E, T14SR17E, T14SR18E, T15SR16E, T15SR17E, and T15SR18E. This information has been forwarded to the Parks. Table 3 lists the wells that lie within or adjacent to the expansion area, the northern section of T15SR17E, and the primary focus of this study. If only one measurement date is given it coincides with the well drilling process. In only five cases were repeat water level measurements taken. Figure 14 illustrates water table elevation and the approximate location of the wells with sufficient location data.



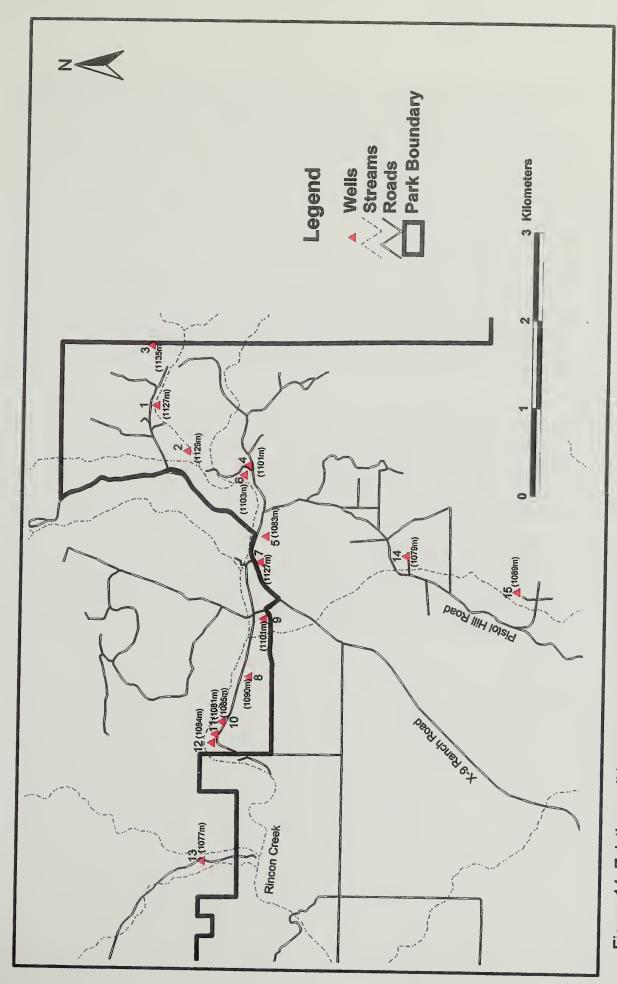


Figure 14. Existing well locations with reported water table elevations (meters above NGD).



The records on file with the Arizona Department of Water Resources are inconsistent between the well registry (55-file) and the Ground Water Site Inventory (gwsi file). Additionally, the water level information in the gwsi file was collected at various times between 1941 and 1995. This limited data suggests that the regional groundwater table is hydraulically connected with the groundwater in the alluvium of the middle basin area of Rincon Creek. The water levels in the wells shown on Figure 14 show a systematic and relatively consistent groundwater gradient to the west. There are three anomalous water levels, with well # 7 and well # 9 being higher than expected and well # 5 being lower than expected. We were not able to determine construction details for well #7, but well # 9 is 139 meters (455 ft.) deep, and its anomalously high water level suggests an upward gradient indicating the bedrock system is discharging into the alluvium. Well # 5 is an 85 meter (280 ft.) deep Rincon Water Company well, and its anomalously low water level may reflect the effects of recent pumping. This well is in one of a series of small faultdammed pockets of alluvium in the Rincon Creek middle basin (Figure 4). Withdrawals from this well would quickly drain this small body of alluvium during the dry months of each year unless the groundwater in the alluvium was also being supported by discharge from the regional groundwater system.

It is difficult to say anything more definitive from the sparse data available. Most data is pre-1990s before development of the area and recorded in the winter when water levels are both higher and of less importance to the deciduous riparian community. It is important to note that from a plant community perspective depth to groundwater is the crucial factor. Wells located adjacent to Rincon Creek in the alluvium deposits exhibit relatively high water levels (Wells 7, 8, 9, 10, and 12). Depth to groundwater increases sharply as one moves away from the Creek (Wells 5,14, and 15). Wells located in the smaller tributaries above X 9 Ranch Road have intermediate water levels probably in response to a more limited storage capacity and less water moving through the individual washes (Wells 1, 3, 4, and 6). Monitoring existing groundwater levels along Rincon Creek in the Expansion Area is mandatory to understanding and quantifying the annual and seasonal variability in groundwater behavior as well as its position in relation to the plant community.



Table 3. Groundwater well locations, depth and water table elevations in or near the Saguaro National Park expansion area, Tucson Az.

	Park expansion a			,
Well Location	Figure 12 well number	Depth to water Meters (ft)	Water Elevation Meters (ft)	Date measured
T15 R17 8 CDA		22.1 (72.5)	1086 (3123)	1/82
		19.7 (64.7)	1089 (3130)	12/87
		13.9 (45.5)	1096 (3150)	1/95
T15 R17 10 CAD	1	6.8 (22.31)	1127 (3238)	8/66
		7.7 (25.2)	1126 (3235)	12/81
		8.2 (26.8)	1125 (3233)	12/87
T15 R17 10 CC	2	1.8 (5.92)	1129 (3244)	4/41
T15 R17 10 DAD	3	5.4 (17.85)	1135 (3262)	8/66
T15 R17 10 CAA		7 (23)	\	5/20
T15 R17 15 BCB	4	17.2 (56.45)	1101 (3164)	12/56
T15 R17 15 ADB		4 (13)		1/98
T15 R17 16 ACC	5	23.6 (77.57)	1083 (3113)	4/63
		16.8 (55.2)	1085 (3118)	12/87
		19.4 (63.7)	1088 (3127)	12/81
		22.4 (73.4)	1091 (3136)	4/65
T15 R17 16 ADA	6	9.3 (30.4)	1103 (3170)	12/87
T15 R17 16 BD	7	1.7 (5.48)	1112 (3195)	4/41
T15 R17 16 AAD		86.9 (285)		1/80
T15 R17 16 ACA		70.1 (230)		9/93
T15 R17 16 ACD		24.1 (79)		3/62
T15 R17 16 ADC		19.5 (64)		6/68
T15 R17 16 BAD		3.7 (12)		1/25
		20.4 (67)		2/98
T15 R17 16 BCB		41.1 (135)		2/87
T15 R17 17 ACB	8	2.1 (6.86)	1090 (3132)	8/66
T15 R17 17 ACB		3.7 (12)		6/65
T15 R17 17 ADD	9	2.1 (6.86)	1101 (3163)	8/66
T15 R17 17 BAB	10	2.2 (7.12)	1085 (3118)	8/66
T15 R17 17 BBA	11	5 (16.3)	1081 (3106)	12/81
		3.8 (12.5)	1082 (3110)	12/87
		1.4 (4.7)	1085 (3117)	1/95
T15 R17 17 BBB	12	1.1 (3.64)	1084 (3116)	8/66
T15 R17 17 ADC		4.3 (14)		7/64
T15 R17 17 BBD		3.7 (12)		5/64
T15 R17 17 BBD		3 (10)		6/58
T15 R17 18 BAB	13	9.8 (32)	1077 (3096)	1/95
T15 R17 18 AAD		106.7 (350)		6/96
T15 R17 18 AD		50.3 (165)		
T15 R17 18 AD		4.6 (15)		9/75
T15 R17 18 ADC		25.9 (85)		6/99
T15 R17 21 BDD	14	63.6 (208.6)	1079 (3101)	12/81
		60.3 (197.9)	1083 (3112)	12/87
T15 R17 28 BAC	15	79.7 (261.5)	1089 (3130)	1/95



## Tanque Verde Creek

The details of groundwater table declines in the Tanque Verde Creek area are very complex due to variations in both time and space of pumping stress. An analysis of the decline in pumping water levels for 15 wells operated by Tucson Water shows a cumulative average decline of 17.1 m (56 ft.) from September 1994 to September 2000, and an average decline in the past year of 7.3 m (24 ft.) (Table 4). The closest of these large municipal wells to the middle basin area tributary that extends into the Park is over 3.2 km downstream. Stromberg et al. (1992) reported a decline of two meters (6.5 ft.) at Wentworth Road, 1.2 km downstream from the tributary, between January 1986 and January 1990. Further downstream outside of the current study area, in the vicinity of the municipal wells in the lower basin area, they reported declines of 18 meters (59 feet) over the same period of time.

While the distance from the large municipal wells is small enough that the effects of their pumping could be felt on the lower portions of the tributaries, the permeable Pliocene and Pleistocene alluvial sediments become much thinner above the junction of Aqua Caliente Wash with Tanque Verde Creek (Stromberg et al., 1992). This may well dampen the effects of the municipal pumping stress in the vicinity of the tributary in Section 9 as suggested by the differences in the amounts of decline noted above. A private well in the tributary in the NE 1/4 of the NE 1/4 of Section 9, within the Park boundary, has a reported drop of 10.1 meters (from 4.6 to 13.7 m) in the past year followed by a rapid recovery to 4 m after heavy, fall rain events (written communication from G. Urias to F. Walker, 8/17/00; verbal communication G. Urias, 11/10/00). This amount and rate of water-level decline and recovery seems unusually large if associated with the municipal pumping and is not consistent with the findings of Stromberg et al. (1992) for the area near Wentworth Road.

### **RESULTS: ECOLOGY**

A number of factors including hydrology, elevation, climate, geology and geomorphology interact to produce a great diversity of physical conditions and thus a great diversity of riparian ecosystems differing in size, species composition, and community structure. Groundwater and surface water availability, magnitude and frequency of flood flows, and water quality combine to play a primary role in influencing the composition, structure and abundance of riparian vegetation between and within these ecosystems (Stromberg, 1994).

Depths to groundwater and inundation frequency exert the greatest influence on plant composition within riparian areas. In arid region floodplains, depth to groundwater influences species composition largely due to species differences in rooting depth combined with the fact that shallow groundwater supplies the permanent water source



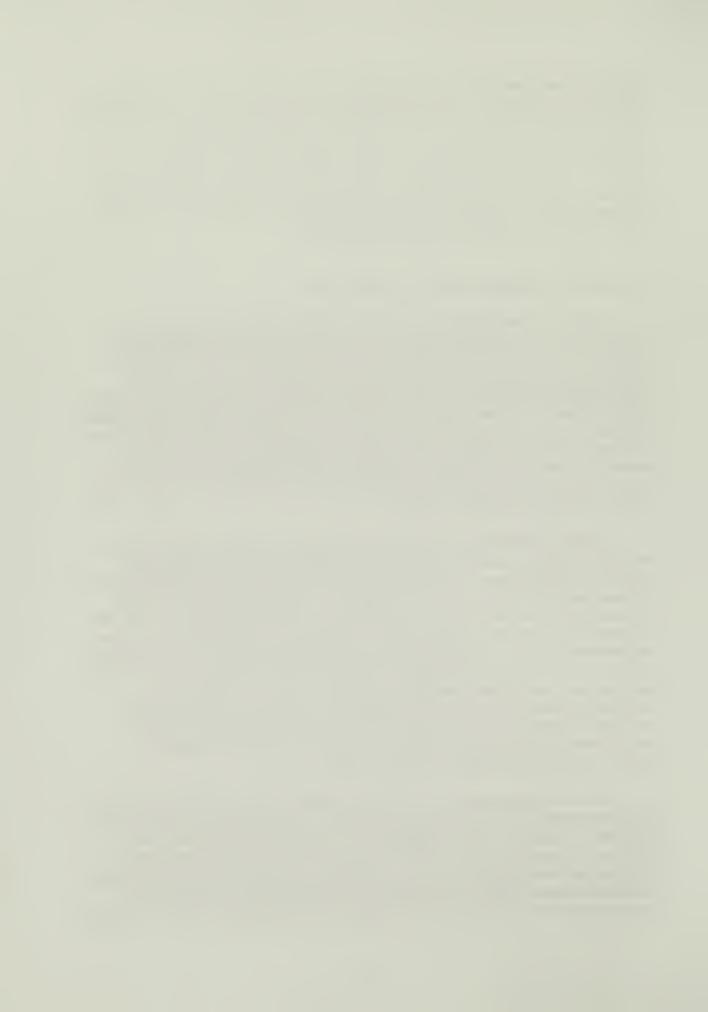
required for tree growth and survival (Stromberg et al., 1996). Climatic factors such as precipitation, temperature, and evaporation rate vary with latitude and longitude and with elevation and influence riparian vegetation by controlling the availability and distribution of water. In Arizona, mid-elevation zones (approximately 1,500 to 2,000 m) are dominated by Arizona walnut (*Juglans major*), velvet ash (*Fraxinus pennsylvanica*), and Arizona sycamore (*Platanus wrightii*). Lower elevations support Fremont cottonwood (*Populus fremontii*), Goodding willow (*Salix gooddingii*) and honey or velvet mesquite (*Prosopis juliflora* or *P. velutina*) (Stromberg, 1994). Two of the more crucial riparian habitat types found within the Park are discussed below.

#### SONORAN COTTONWOOD- WILLOW ASSOCIATIONS

Forests of Fremont cottonwood and Goodding willow once thrived within the floodplains of low-elevation rivers of Arizona, California, Utah and northern Mexico, historically covering hundreds of kilometers. These cottonwood-willow associations often occur as a mosaic with other riparian types including Sonoran interior marsh, Sonoran riparian scrubland, and Sonoran riparian mesquite. Tree species diversity within cottonwood-willow forests is generally low, but age class and structural diversity is often high. Depending on the past history of flooding or other disturbance the understory can be dense or open and park-like. Most cottonwood-willow stands contain a mix of perennials and annuals, and of exotic and native species (Stromberg, 1993a). Today, Sonoran riparian cottonwood-willow associations are among the most threatened forest types in the United States (Swift, 1984).

Riparian ecosystems develop along floodplains of low gradient alluvial streams where depositional environments of fine-grained alluvial substrates are optimal for riparian forest establishment. Large amounts of viable cottonwood and willow seeds are produced yearly, so propogule source is generally not a limiting factor in recruitment (Johnson, 1994). Recruitment sites for willow and cottonwood seedlings are moist, bare of vegetation and exposed to full sunlight. These conditions are associated with recent sediment events, point bars of meander lobes, and migrating edges of rivers (Bradley and Smith, 1986). Stromberg (1993b) reported that floods with a magnitude equal to at least the seven-year event appeared necessary to remove a sufficient percentage of the competing herbaceous cover and allow cottonwood and willow seedlings to become established in Southern Arizona's riparian systems. In these dry regions, the early establishment and growth of seedlings also requires that seedling roots stay within contact of water tables (Mahoney and Rood, 1992).

Riparian communities are dependent upon specific, dynamic surface water and groundwater requirements for their daily physiological needs (long-term survival) as well as regeneration (Richter, 1992). Quantitative information on the extent and timing of functional responses and mortality of *Populus* and *Salix* to groundwater depletion are rarely matched with information on the rate, depth, and duration of water table declines. The reported mean depths to groundwater for mature *Populus fremontii* and *Salix* gooddingii are  $1.5 \pm 1$  m and  $1.4 \pm 0.9$  m respectively (Stromberg et al 1996). Floodplain



accretion or channel incision can increase depth to water over time. While extensive root development in mature trees may allow trees to survive such gradual water table declines, riparian habitats are generally restricted to areas where depth to water table is  $\leq$ 3.5 meters (Scott et al., 1999).

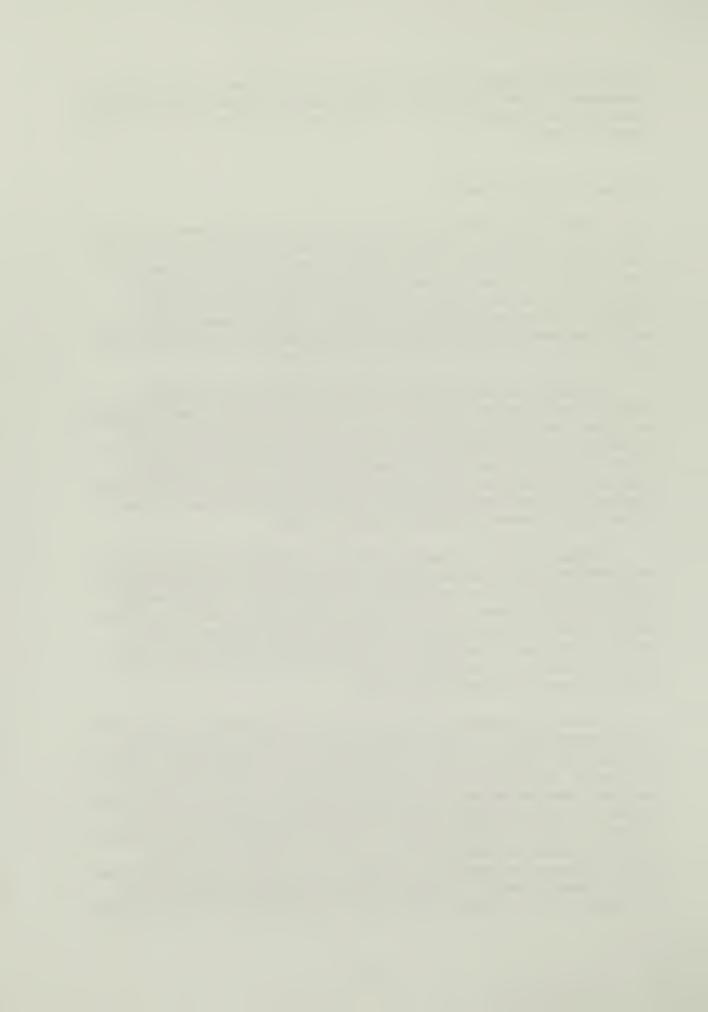
### SONORAN RIPARIAN MESQUITE

Prosopis velutina (velvet mesquite) is a facultative riparian species native to the Sonoran region. Existing as shrubs in arid habitats, mesquite develop into trees reaching their maximum size and cover in riparian habitats. Access to a permanent water source (high groundwater) allows P. velutina to form closed-canopy forests or bosques in conjunction with species including Celtis reticulata, Juglans major, and Zizpyhus obtusifolia. The productivity, biomass and diversity of riparian mesquite bosques are an order of magnitude higher than in uplands. Shallow groundwater allows these mesquite trees to escape the normal water limitations of an arid system.

Recognition that the growth form of *Prosopis velutina* varies with water availability is not a new one. As far back as 1884, Harvard noted that where groundwater was within 15 meters of the surface *Prosopis* occurred as a tree rather than a shrub (Stromberg et al., 1993). While in 1927, Meinzer reported that the canopy height of riparian mesquite varied with depth to groundwater (Meinzer, 1927). Historically, bosques covered more land area than any other riparian type in the Southwest. Today in large part due to water development, the few remaining mesquite bosques have been reduced to small, remnant patches (Stromberg et al., 1993).

Riparian mesquite communities experience severe to lethal stress with declining water tables as a result of their dependence on alluvial groundwater. Roots of riparian mesquite typically develop within the upper five meters of the soil surface, extending only into the capillary fringe above the generally shallow phreatic zone. The potentially high growth rate of mesquite roots does not ensure success in response to rapidly declining water tables, as floodplain soils in the arid Southwest often consist of coarse-textured alluvium that does not readily maintain the moist continuum necessary for inducing deeper roots (Stromberg et al., 1992).

Concern over groundwater mining from the basin supporting lower Tanque Verde Creek generated a study on the effects of declining water tables on *Prosopis velutina*. Stromberg et al. (1992) found that predawn and midday plant water potential, leaflet size, leaflet number, tree height, and dead canopy percentage varied linearly with depth to water table, while total vegetation volume varied non-linearly. The authors conclude that the effect of groundwater decline is one of incrementally increasing stress and habitat degradation, ultimately reaching lethal levels. They observed healthy bosque responses only where groundwater levels were <5 meters below the surface. Tree response declined continuously as groundwater receded to 15-18 meters. At greater depths, trees became increasingly stressed. The authors were quick to point out that these results apply only to large, mature trees. Young mesquite trees have limited rooting depths and



were noted to be under lethal or sub-lethal stress in areas where mature mesquite trees were only moderately stressed (Stromberg et al., 1992).

#### **EFFECTS OF DROUGHT STRESS**

Riparian ecosystems respond to stress by undergoing changes at increasingly larger scales. With low levels of stress, changes often occur at the individual or population levels. Riparian trees experience increases in physiological stress, declines in growth, outbreaks of disease, or increases in mortality and declines in population density. Higher levels of stress cause ecosystems and community-level changes (loss of species), changes in vegetation structure (reduction in canopy cover or replacement of tall forests by shrublands) and reduction in biomass. The reduction or loss of one species can have a cascading effect throughout an ecosystem due to the interdependency of riparian species. Extreme stress levels can result in riparian forests being replaced with desert vegetation or barren soil (Stromberg, 1994).

The response of an individual plant to gradually increasing water stress involves progressive and integrated physiological and morphological responses, beginning with stomatal closure, reduced leaf and canopy development, and ending with death. Plant productivity is reduced as a result of lowered net photosynthesis, and through the death of leaves and fine roots. Under more severe drought conditions trees exhibit reduced radial stem increments, wilting and abscission of leaves, and branch death. Tree mortality may follow directly or as the result of insects or other pathogens. Monitoring annual branch growth may be one of the best indicators of sub-lethal water stress (Scott et al., 1999).

An integrated understanding of surface and groundwater dynamics in relation to the reproduction and maintenance of riparian plant species is required for effective riparian conservation and management (Scott et al., 1999). In conjunction with monitoring groundwater conditions, habitat monitoring is highly recommended. Early signs of habitat degradation or stress can be detected by monitoring these factors at the following scales (Stromberg, 1994).

## A) Monitor individual plants for:

- reduction in growth rate
- changes in physiological state (increases in internal plant stress)
- increases in canopy mortality
- increased outbreak of pathogens or disease organisms.

# B) Monitor plant populations for:

- reduction in age class diversity
- increases in plant mortality for susceptible age classes.



## C). Monitor communities for:

- changes in cover or biomass
- loss of biodiversity
- changes in species composition
- increased abundance of exotic species
- decreased abundance of "keystone" species
- decreased abundance of indicator species that are sensitive to ecosystem changes and serve as early warning detectors of stress.

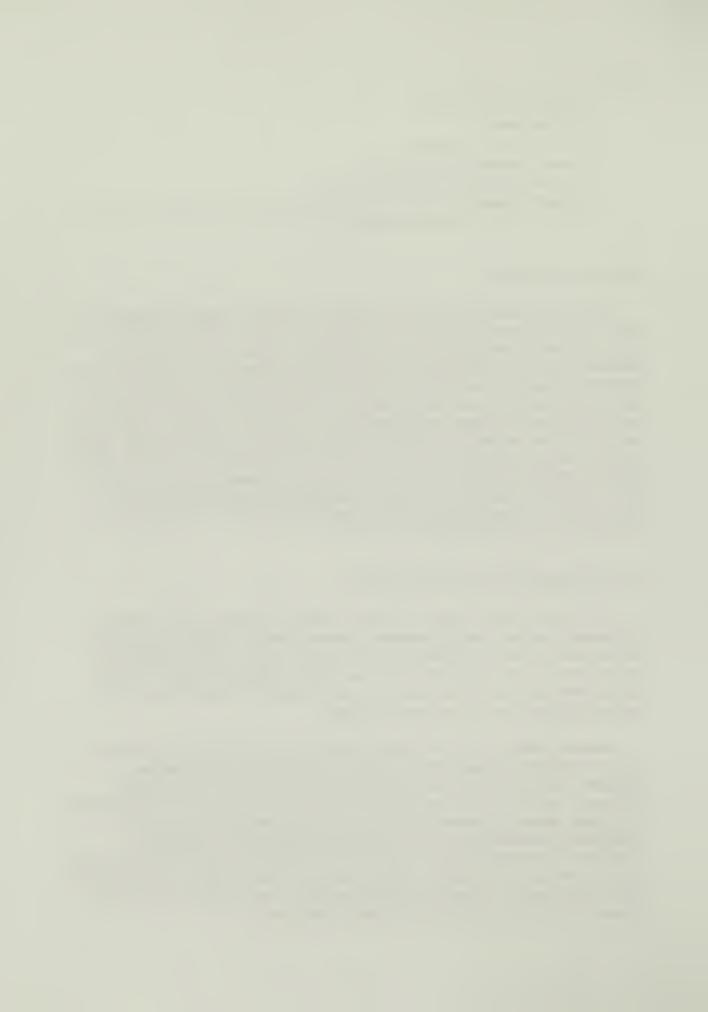
## AREAS OF CONCERN

The long-term health and survival of riparian habitats within Saguaro National Park depends upon an assured water source. Groundwater levels must stay within the rooting zone of the trees for the majority of the growing season, while recruitment events are dependent upon flood events that coincide with high groundwater levels. The first step in determining required groundwater elevations is to establish a critical extinction depth or depth below which the groundwater should not fall. To do this one needs to focus on the zone of groundwater utilization by the riparian trees growing in these areas. The roots of most riparian trees are largely restricted to the upper 6 meters of the soil horizon. Bosque mesquite trees are reported to have taproots down to 9 meters (Judd et al. 1971). Once groundwater levels drop below the root zone, the trees are unable to extract it. If water levels remain below this extinction depth for prolonged periods during the growing season, decline and eventual death of the riparian community follows (Judd et al., 1971; Stromberg et al., 1996; Stromberg et al., 1993).

#### RINCON CREEK: HIGH GRADIENT REACHES

The upper basin area of Rincon Creek and its tributaries can best be described as high-gradient, bedrock-controlled streams or washes. These are effectively cut-off from the lower alluvial basin by the series of bedrock dams described earlier. Behind these series of bedrock dams small pools develop and support patches of vegetation. While each individual area may not be extensive, together they form a critical resource for the regional wildlife and to the functioning of the Park.

Chimenea, Madrona and upper Rincon Creeks all support valuable habitats (Figure 15). At the higher elevations, 1000-1220 meters, mixed narrow leaf community dominates. This habitat type is characterized by *Prosopis velutina*, *Acacia greggii*, *Parkinsonia* spp., *Chilopsis linearis*, *Celtis spp.*, *Baccharis salicifolia*, and *Cephalanthus occidentalis*. Based on previous mapping efforts *Gossypium thurberi*, *Jatropha cardiophylla*, *Muhlenbergia* spp., *Celtis pallida*, and *Lysiloma microphylla* also contribute to this vegetation type. Considered a xeroriparian community, this habitat type is an important resource to the Park. Below 1000 meters, these reaches are dominated by a more typical riparian community of *Platanus wrightii*, *Fraxinus velutina* and *Populus fremontii* with pockets of just *Fraxinus velutina* interspersed.



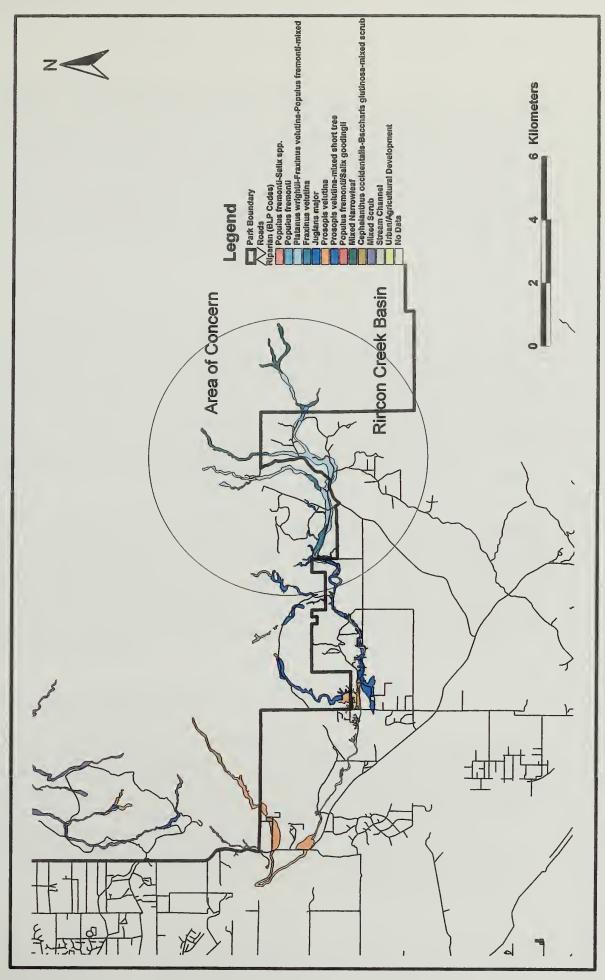


Figure 15. Riparian areas: Rincon Creek and tributaries.



Threats: Groundwater removal in the middle and lower basin areas is not likely to affect these areas. However, these areas are very susceptible to increased sedimentation or erosion caused by changes in land use. Increased numbers of visitors to the areas and/or introduction of mountain bikes will likely trigger increased erosion of the hillslope. Results of our recent field surveys indicate that an erosion problem already exists within the Park. Head cutting and gully formation is occurring along many of the trails as well as on the surrounding hillslopes. Increased sedimentation from the surrounding hills may fill these small pools, displacing the riparian vegetation growing in these areas and eliminating important water sources for wildlife.

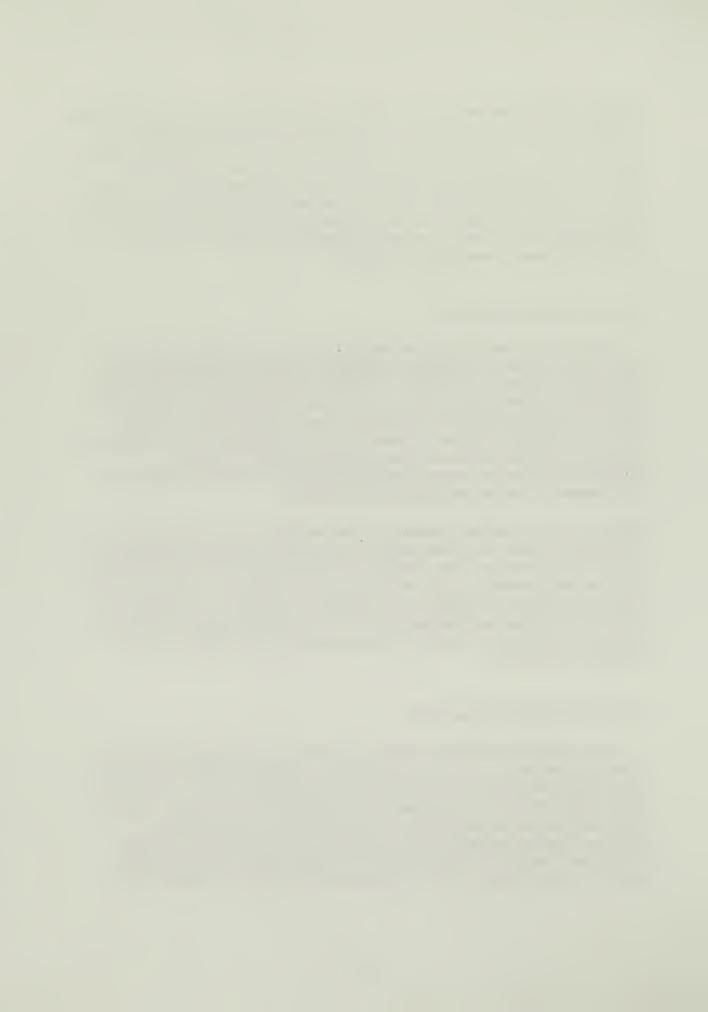
## TANQUE VERDE TRIBUTARIES

The upper basin area tributaries of Tanque Verde Creek are similar in nature to the Rincon Creek tributaries. The major community type along these tributaries is mixed upland scrub. Patches of *Cephalanthus occidentalis*, *Baccharis glutinosa*, and *Populus fremontii* were located along the tributary adjacent to Douglas Springs trail (Figure 16). However, the riparian community of primary concern is a low elevation mesquite bosque. This bosque is supported by flows from several tributaries as they converge just above their confluence with Tanque Verde Creek (Section 9, T. 12, R. 14). Approximately 60% of the mesquite bosque is located within the Park boundary while the remaining area extends north of the Park's boundary.

Threats: There is extensive development of the groundwater resource in the alluvium in the portion of Tanque Verde Creek which runs from east to west a short distance to the north of the Park boundary. The development includes both private wells for homes and resorts, as well as municipal supply wells operated by Tucson Water. The small riparian areas growing at higher elevations on the northern slope of Tanque Verde Ridge are isolated from effects of this development. However, the riparian bosque is hydraulically connected to the alluvium of Tanque Verde Creek and is being impacted by these groundwater extractions.

#### RINCON CREEK: MIDDLE REACHES

The lower portions of Chimenea, Madrona and the middle reach of Rincon Creeks support the finest and most extensive riparian habitat remaining in the Park (Figure 17). At these lower elevations, Rincon Creek is a low-gradient alluvial stream. The channel widens slightly and the limited saturated alluvium supplies some groundwater storage capacity to the system and allows for the development of Sonoran cottonwood-sycamore-willow association along the streambank. However, current groundwater development is placing stress upon the system. Field investigations revealed signs of water stress in mature trees, as well as a general lack of seedling recruitment. This



coupled with the transition to a more xeric community that is occurring away from the creek bank should be taken as a serious warning signal.

Threats: Fairly extensive groundwater development of the area has already occurred. Private wells for homes exist in the larger alluvial pockets in Chimenea and Madrona Creeks. Numerous private wells now draw water from the alluvium supporting Rincon Creek and as the area continues to develop additional wells may be requested. Groundwater development from the alluvium upstream on the X9 Ranch will diminish the flow through this reach. If most of the water is used for domestic purposes in the X9 development, and the water is returned through septic tanks then much of the water is simply being re-circulated in the groundwater system above the park boundary. However, the timing of the flow through the system is affected particularly in the drier months, as domestic use has a seasonal variation, with more water used in the hotter months. Increased domestic water use during the hot, dry months places additional stress on an already stressed riparian system. The extent and ultimate result of such increased stress will vary with current climatic and groundwater conditions. If however, the water is exported down-valley, groundwater levels will decline and the subsequent loss of riparian habitat is inevitable.

If the habitat is to be preserved, additional water extraction due to development of new wells, increased pumping from existing wells or transfers of water out of the immediate vicinity need to be prevented. If groundwater depths fall below 3.5 meters during a significant portion of the growing season remedial action will be required if the habitat is to survive. If the timing and/or intensity of flood flows in the creek are altered, recruitment events will also be affected. Reductions in either will result in fewer successful recruitment years. In order to preserve future recruitment events, natural surface flow should be preserved.



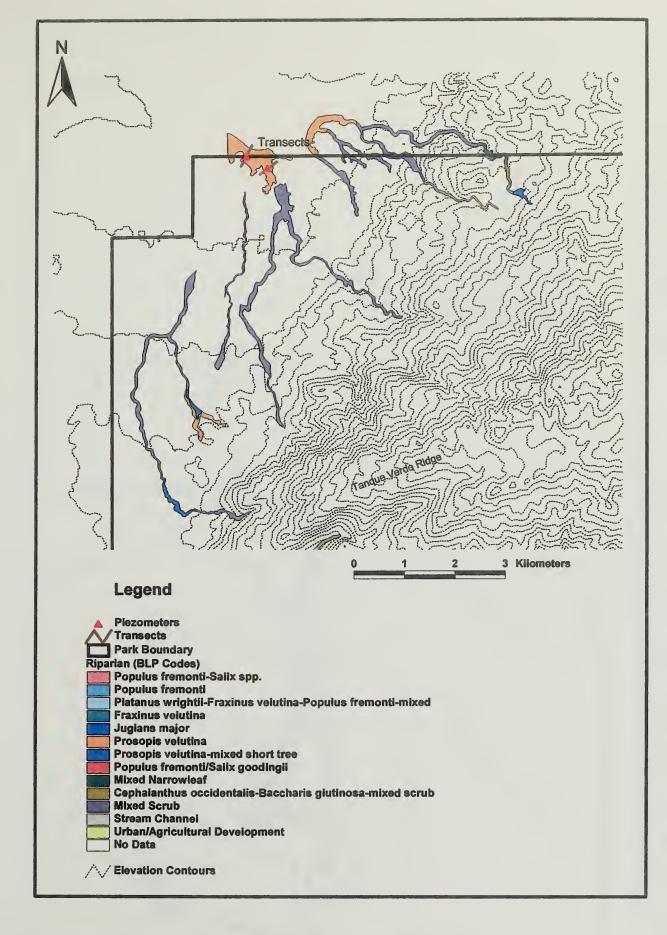


Figure 16. Riparian areas: Tanque Verde Creek tributaries.



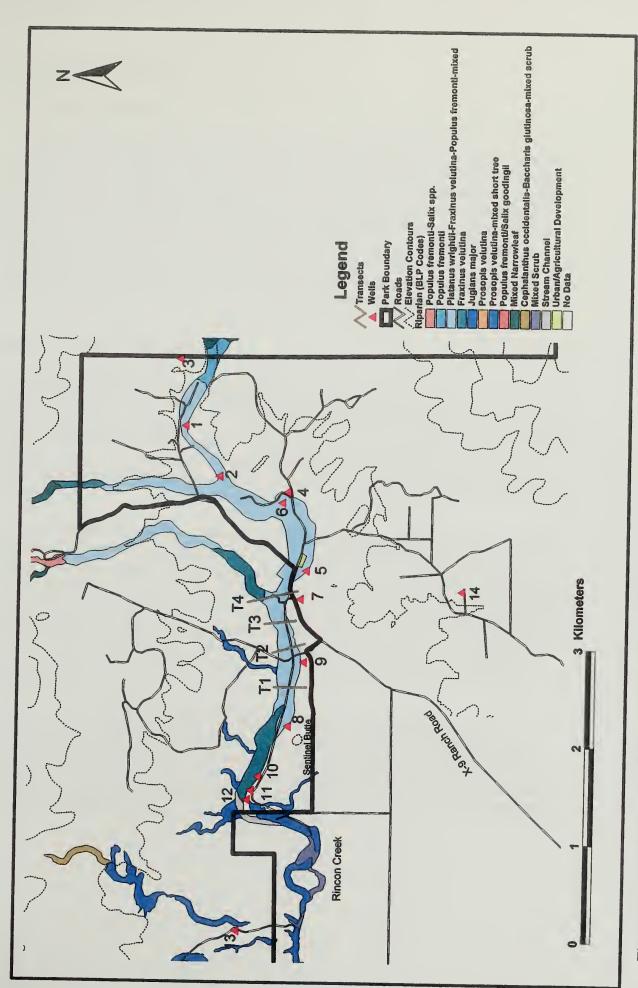


Figure 17. Middle basin riparian areas: Rincon Creek.



#### RECOMMENDATIONS

## **Groundwater Monitoring**

Monitoring of groundwater in the X9 Ranch area of Rincon Creek and the mesquite bosque in Tanque Verde tributary is strongly recommended. Two shallow piezometers should be installed adjacent to Rincon Creek; one upstream of the existing abandoned well and the other downstream (Figure 17). Two piezometers should be installed along the central axis of the Tanque Verde tributary bosque (Figure 16). See Hydrologic Monitoring Manual (The Nature Conservancy, 1996) for suggested piezometer construction. Monthly groundwater readings from all three Rincon Creek points (two piezometers and abandoned well) and the two Tanque Verde points should give an adequate picture of the groundwater conditions in the areas of concern.

## **Monitor Streambed Morphology**

Changes in sediment movement and storage can have significant effects on the stability and health of the smaller hill slope riparian patches and on the lower unconfined portions of Rincon Creek and Tanque Verde tributary. Conducting annual cross-sectional surveys of the existing morphology of the stream channel and selected upper reach riparian patches is recommended. Repeated inventories will quantify how urbanization and/or increased park usage is altering the system and may allow for early preventative measures.

Four perpendicular transects should be established along Rincon Creek from the X9 Ranch road to Sentinel Butte (Figure 17). Two perpendicular transects should be established in conjunction with the monitoring wells in the Tanque Verde bosque (Figure 16). Transects should extend to the outside edge of the riparian vegetation where feasible. Cross-sectional profiles need to be measured using a transit and leveling rod. Elevation readings should be taken at all significant changes in the bank morphology. Permanent markers should be placed at both ends of each transect and at its intersection with the stream. The placement of markers should be documented with a Global Positioning System (GPS).

In the smaller pools any significant change in depth of fill should be carefully examined and the source of sediment identified. If the sediment is from erosion of the surrounding hillslope remedial action should be taken immediately to halt the erosion. Along Rincon Creek itself, significant bank sloughing or the formation of head cuts may be caused by changes in run off patterns from the surrounding area or the development of nick points within the stream and should be mitigated.



## **Habitat Monitoring**

In conjunction with monitoring groundwater conditions, habitat monitoring is required for effective riparian conservation and management. Biennial riparian vegetation monitoring should be conducted along the same transects established for hydrologic monitoring. Spring and late summer surveys are needed to capture the seasonal change in annual species as well as response of the habitat to late summer water stress. A list of suggested study parameters is given below. Vegetative and/or habitat parameters should then be correlated with the measured hydrologic variables.

## **Suggested Monitoring Outline**

**Task 1. Groundwater**: Record monthly water level readings from 5 monitoring wells or piezometers described above.

Task 2. Streambed: Annual cross-sectional survey of the four transects on Rincon Creek (locations noted on Figure 17), on selected upper watershed tributaries of Rincon (locations to be field determined) and the two Tanque Verde bosque transects (Figure 16).

**Task 3. Vegetation**: Biennial vegetation surveys at all locations established for task 2. Suggested habitat parameters are listed below and vary with season.

## Early summer survey

# Overstory Vegetation

Percent cover by species

Species composition

Diameter Breast Height (DBH)

Tree height

Annual branch growth

Vegetation volume: live and dead (or foliage height diversity)

Percent native species

Percent of species in each USFWS wetland plant indicator status

Percent of canopy dead

Percent of trees diseased or with visual evidence of pathogens

Number of young recruits

# **Understory Vegetation**

Species composition

Percent cover by species

Percent of species in each USFWS wetland plant indicator status

Presence/absence of surface water



## Late summer survey

## Overstory Vegetation

Vegetation volume: live and dead (or foliage height diversity)

Percent of canopy dead

Percent of canopy stressed: yellow and/or wilted leaves

Percent of trees diseased or with visual evidence of pathogens

Number of surviving young recruits

## **Understory**

Species composition

Percent cover by species

Percent of species in each USFWS wetland plant indicator status

Presence/absence of surface water

#### POTENTIAL REMEDIAL ACTIONS

Groundwater development has and continues to impact the riparian areas within the Park boundary. At greatest risk is the reach of Rincon Creek between the X9 Ranch and the western boundary of the Parks expansion area, and the tributary riparian system of Tanque Verde Creek. The present levels of off-Park pumping stress are having a greater impact on the Tanque Verde tributary than on the Rincon Creek riparian area, but both areas have similar protection/mitigation strategies.

The most important thing that could be done, particularly in Tanque Verde Creek, is to encourage Tucson Water to expand its service area into the wash, and eliminate as many pumping wells as possible. This would have the effect of bringing supplemental water into the area in addition to the amount entering under natural conditions.

The second most important thing (perhaps most important in Rincon Creek) is to take whatever steps are necessary to prevent additional groundwater pumping and the export of water from the vicinity of the Park, particularly if the export is to downstream areas. This includes both pumped groundwater and wastewater. This would have the effect of retaining more water to benefit the Parks' riparian resources, and would be particularly effective if water for areas adjacent to, and upstream from, the Park's riparian areas was from an imported source.

Another mitigating measure would be to discourage the expansion of waste-water collection systems into the area, which would have the effect of increasing the annual water supply if water is delivered to the area from remote sources.

If possible, the importation of treated waste water to the upper ends of the middle reaches of Tanque Verde and Rincon creeks would also be of beneficial effect to the health of the riparian vegetation.



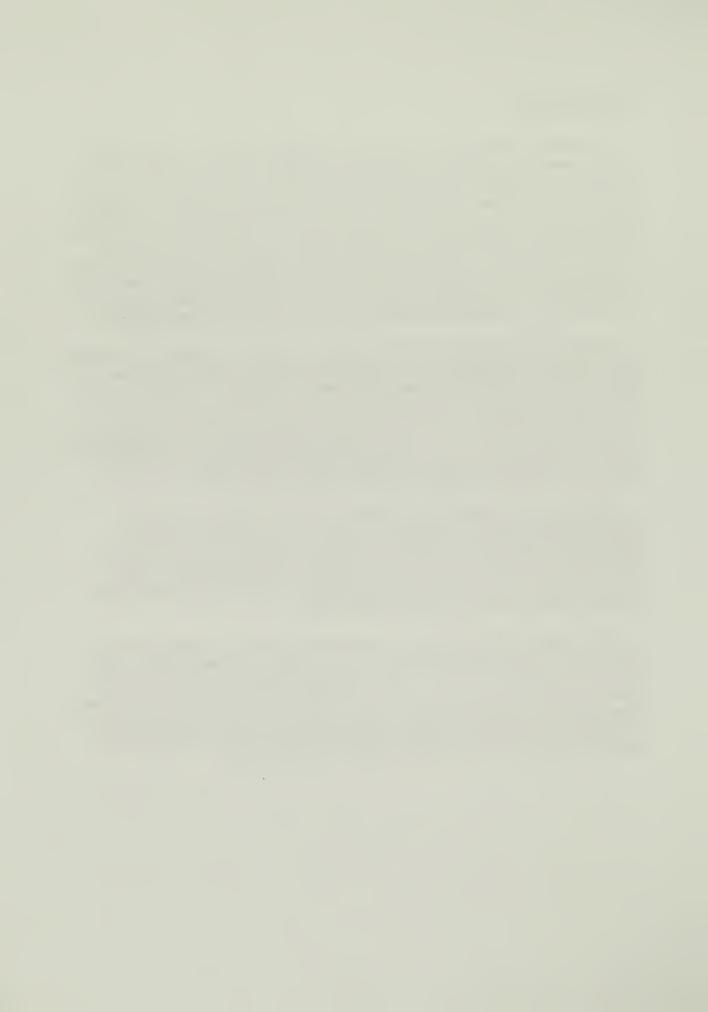
#### **CONCLUSION**

The geologic framework of the Tanque Verde Ridge and the Rincon Valley exerts strong control on the hydrology of the riparian systems of the Saguaro National Park. Pantano fault constitutes a line of hydrogeologic separation between the occurrence and utilization of groundwater in the Rincon Valley and the main Tucson basin. Therefore, the groundwater reservoirs supporting the riparian areas within Rincon Mountain District are not directly connected to the Tucson basin aquifer. The upper reaches of Tanque Verde and Rincon Creeks, tributaries and other small washes that lie within the Park can best be described as high-gradient, bedrock-controlled streams or washes. These areas are effectively cut-off from the lower alluvial basin by a series of bedrock dams, but are very susceptible to increased sedimentation or erosion caused by changes in land use.

The riparian habitat adjacent to Rincon Creek through the X9 Ranch area to Sentinel Butte is the best remaining cottonwood-willow riparian habitat within the Park and one of two areas most threatened by increased groundwater development. This short reach of Rincon Creek lies within the Saguaro National Park boundary in an area where the outcrop of the Catalina Fault is in close proximity on both sides of the stream valley. The second threatened habitat is the mesquite bosque growing along the northern boundary of the Park in a tributary of Tanque Verde Creek. These habitats possess high wildlife values and are important to the functioning of Saguaro National Park.

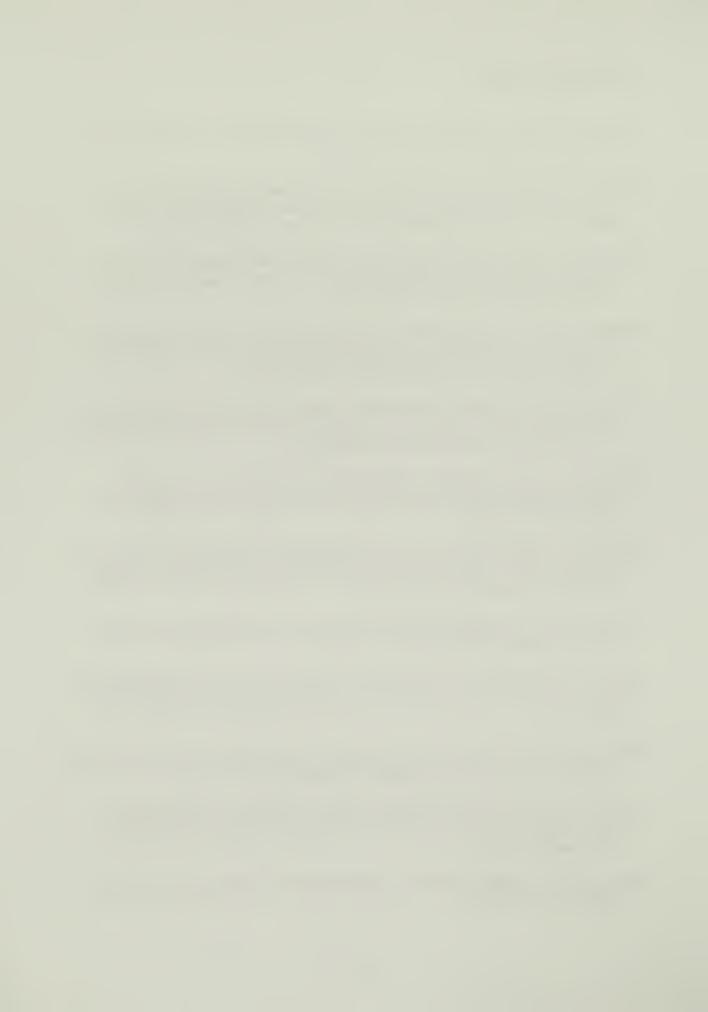
Extensive development of the groundwater resources in and near the alluvium underlying Rincon and Tanque Verde Creeks threaten these valuable resources. Development includes both private wells for homes and resorts, as well as municipal supply wells operated by Tucson Water. Monitoring monthly groundwater levels, conducting annual cross-sectional surveys of existing stream channel morphology and riparian habitat monitoring is strongly recommended.

If groundwater depths fall below 3.5 meters in Rincon Creek or 5 meters in Tanque Verde Creek during a significant portion of the growing season remedial action will be required if the habitat is to survive. If the timing and/or intensity of flood flows in the creek are altered, recruitment events will also be affected. Reductions in either will result in fewer successful recruitment years. If the habitat is to be preserved additional water extraction due to development of new wells, increased pumping from existing wells or transfers of water out of the immediate vicinity must be prevented.



#### LITERATURE CITED

- Arnold, L.W. 1940. An ecological study of the vertebrate animals of the mesquite forest. M.S. thesis, University of Arizona. Tucson, AZ.
- Briggs, M., M. Schmid, and B. Halvorson. 1996. Monitoring riparian ecosystems, An inventory of riparian habitat along Rincon Creek near Tucson, Arizona. Arizona Game and Fish Department Heritage Project Number U94018 Final Report.
- Bradley, C.E., and D.G. Smith. 1986. Plains cottonwood recruitment and survival on a prairie meandering river floodplain, Milk River, Southern Alberta and Northern Montana. Canadian J. Bot. 64:1433-1442.
- Burkham, D.E. 1970. Depletion of streamflow by infiltration in the main channels of the Tucson basin, Southeastern Arizona. U.S. Geological Survey Water Supply Paper 1939-B, U.S. Government Printing Office, Washington D.C.
- Davidson, E.S. 1973. Geohydrology and water resources of the Tucson basin, Arizona: Water resources of the Tucson basin. Geological Survey Water Supply Paper 1939-E. U. S. Government Printing Office, Washington D.C.
- Halpenny, L.C., and P.C. Halpenny. 1985. Evaluation of adequacy of groundwater supply, Ranchlands Water Company, Rincon Valley, Pima County, Arizona. Water Development Corporation.
- Hastings, J.R., and R.M.Turner. 1962. The Changing Mile, An Ecological Assessment of Vegetation Change with Time in the Lower Mile of an Arid and Semi-arid Region. University of Arizona Press. Tucson, AZ.
- Johnson, W.C. 1994. Woodland expansion in the Platte River, Nebraska: Patterns and causes. Ecological Monographs 64(1): 45-84.
- Judd, B.I., J.M. Laughlin, H.R. Guenther, and R. Handegarde. 1971. The lethal decline of mesquite on the Casa Grande National Monument. Great Basin Naturalist 31: 153-159.
- Mahoney, J.M., and S.B. Rood. 1992. Response of a hybrid popular to water table decline in different substrates. Forest Ecology and Management 54: 141-156.
- Mac Nish, R. and D.P. Guertin. 1997. Plan of study to characterize the hydrology of riparian areas in SAGUARO NATIONAL PARK and evaluate potential effects of anthropogenic stresses.
- Meinzer, O.E. 1927. Plants as indicators of groundwater. U.S. Geologic Survey Water Supply Paper 577:95 pp.



- Mott, David N. 1997. Saguaro National Park, Arizona Water Resources Scoping Report. Technical Report NPS/NRWRD/NRTR-97/95. United States Department of the Interior, National Park Service.
- The Nature Conservancy. 1996. Hydrologic monitoring manual, Version 4.0. The Biohydrology Program Conservation Science Division. Arlington, Virginia.
- Osterkamp, W.R. 1973. Groundwater recharge in the Tucson area, Arizona: U.S. Geol. Survey Misc. Inves. Series Map I-844-E, 1 sheet.
- Richter, H.E. 1992. Development of a conceptual model for floodplain restoration in a desert riparian system. Aridlands Newsletter 32:13-17.
- Rogers, S. 1987. Hydrologic investigation of the northeast area of the Tucson basin, structure, and stratigraphy. Tucson, AZ: Tucson Water Open File Report WRS-87-1.
- Scott, M.L., P.B. Shafroth, and G.T. Auble. 1999. Responses of riparian cottonwoods to alluvial water table declines. Environmental Management 23(3): 347-358.
- Smith, G.E.P. 1910. Ground water supply and irrigation in the Rillito Valley. Agricultural Experiment Station, University of Arizona. Tucson, AZ.
- Stromberg, J.C. 1994. Arizona Protection Program Legislative Report. Arizona Department of Water Resources, Phoenix, Arizona.
- Stromberg, J.C. 1993a. Fremont cottonwood-Goodding willow riparian forests: a review of their ecology, threats and recovery potential. Journal of the Arizona-Nevada Academy of Science 26(3): 97-110.
- Stromberg, J.C. 1993b. Instream flow models for mixed deciduous riparian vegetation within a semiarid region. Regulated Rivers: Research & Management 8:225-235.
- Stromberg, J.C., R. Tiller, and B. Richter. 1996. Effects of groundwater decline on riparian vegetation of semiarid regions: the San Pedro, Arizona. Ecological Applications 6(1): 113-131.
- Stromberg, J.C., S.D. Wilkins, and J.A. Tress. 1993. Vegetation-Hydrology models: implications for management of *Prosopis velutina* (velvet mesquite) riparian ecosystems. Ecological Applications 3(2): 307-314.
- Stromberg, J.C., J.A. Tress, S.D. Wilkins, and S.D. Clark. 1992. Response of velvet mesquite to groundwater decline. Journal of Arid Environments 23:45-58.
- Swift, B.L. 1984. Status of riparian ecosystems in the United States. Water Resources Bulletin 20:223-228.



Thorman, C.H. and H. Drewes. 1981. Mineral resources of the Rincon Wilderness Study area, Pima Co., Az. Part A. Geology of the Rincon Wilderness Creek area, Pima Co. Az. United States Geological Bulletin 1500.

Urias G., Private inholder. Written communication to F. Walker August 17, 2000.

Urias G., Private inholder. Verbal communication. November 10, 2000.



### Appendix A

Riparian Mapping

Saguaro National Park, East

Dr. D. Phillip Guertin



#### RIPARIAN MAPPING

#### INTRODUCTION

The riparian mapping project described below satisfies one task of a larger hydrologic study of riparian areas in Saguaro National Park (SNP) East. This study was initiated as a result of a technical report by David Mott entitled Saguaro National Park, Arizona Water Resources Scoping Report (Mott, 1997). The report outlines growing concerns to critical and unique desert riparian habitat due to ground water depletion as a result of urban growth in the Tucson basin. This mapping project was undertaken to provide baseline digital data of the vegetation communities associated with riparian areas potentially threatened by the urban development surrounding Saguaro National Park (SNP) East. The geographic information system (GIS) coverage produced will be used in conjunction with hydrologic data and vegetative surveys, to monitor changes in riparian systems located within Saguaro National Park East.

Goals of the mapping effort were:

- 1) inventory the major riparian communities located in Saguaro National Park East,
- 2) acquire aerial photography of the riparian areas mapped at a sufficient scale to identify important riparian vegetation features, and
- 3) provide a digital map (Arc/Info format) of the riparian communities attributed with Brown, Lowe and Pase classifications to the association level (Brown, 1994).

Within Saguaro National Park (SNP) East, the riparian and xeroriparian areas within the tributaries of the Rincon Creek and Tanque Verde Creek below 1219 m (4000 ft) tributary were mapped.

#### **METHODS**

The principal goal of this effort was to map riparian vegetation in Saguaro National Park, East to the association level based on the Brown, Lowe and Pace vegetation classification system (Brown, 1994). The process utilized two sets of imagery; U.S. Geological Survey Digital Orthophoto Quarter Quadrangles (DOQQ) and high-resolution videography collected specifically for this project. Other GIS information from previous mapping efforts were also used to assist in the mapping efforts. Table 1 summarizes the information used in this mapping effort.

U.S. Geological Survey Digital Orthophoto Quarter Quadrangles (DOQQ's) were used as the base imagery for the mapping effort. Eight DOQQ's for the U.S. Geological survey 7.5'quadrangles of Tanque Verde Peak and Mica Mountain were obtained and appended together. The advantage of using the DOQQ's is that they are already georeferenced and differentially rectified. The process of differential rectification, which improves the spatial accuracy of the image, was beyond the scope of this project. Hence the DOQQ's provided a more accurate and stable media for the mapping effort. The



DOQQ's used in this effort were black and white, with a pixel resolution of one meter and a horizontal accuracy of approximately 10 meters.

To assist in the mapping effort the riparian corridors were flown with high-resolution videography by Charles Curtis of Sensair, Tucson, Arizona. Two 8 mm videos were obtained; a 45 degree oblique and vertical. The oblique video was used to locate the riparian within the terrain and approximate its extent and variability. The vertical video was useful for identifying individual shrub and tree species. The minimum spatial resolution of the vertical video was approximately 0.2-0.3 meters depending on the terrain and flight height. An attempt was made to fly all the stream reaches in Saquaro National Park East below 1219 m (4000 ft). However due to difficult terrain, a few reaches were unobtainable.

The videos where time stamped using a global positioning system (GPS time in the audio track). The location of each GPS point was then obtained and entered into the GIS. This allows for the identification of those video segments that could aid in the vegetation classification. The GIS coverage of the video flight lines was superimposed on the DOQQ's. In areas were the interpreter was having difficulty classifying the vegetation from the DOQQ's, the interpreter could locate the closest video image based on the GPS points and then forward the video to that point and use both the oblique and vertical video to assist in the classification.

Table 1: Data used in riparian vegetation mapping.

Information Type	Data Source	Data Format	Metadata
Historical Vegetation Map	Pam Anning Saguaro National Park	Paper Map	vegccc.doc
Vegetation Map of Expansion Area	Meg Weesner Saguaro National Park	Paper Map	See SNP project entitled: A vegetation and plant survey of the newly added lands of Saguaro National Park
Hydrology Coverage	Arizona General Reference Library- Web Site	Digital File in Arc/Info format	www.srnr.arizona.edu/uaaiug/docs/hydro.txt
U.S Geological Survey Digital Orthophoto Quarter Quads (Black and White)	Arizona Regional Image Archive – Web Site	Tiff Image	See Appendix D
U.S Geological Survey Digital Orthophoto Quarter Quads (Color)	Pam Anning Saguaro National Park	Tiff Image	Contact Pam Anning
8 mm Aerial Videography Vertical and Oblique	Charles Curtis	High 8 mm Video Tape	See Appendix D

Previous Saguaro National Park vegetation mapping efforts where reviewed in order to familiarize the researchers with the types of the vegetation that might exist within the park. Most notable was the mapping effort by Patty Guertin of the extension area. With this information, field reconnaissance was undertaken. Most of the riparian areas in the eastern portion of the Park below 1219 m (4000 ft) elevation were subsequently walked.



#### Releve Procedure

To assist in the classification of vegetation communities the releve procedure developed for the Arizona GAP program was used. The procedure has been well documented in manuals developed for the GAP project (Bennett et al. nd) and will not be reviewed in detail here. It should be pointed out that the purpose of the releve procedure was to determine the potential riparian vegetation communities present in the Park and to assist in training the aerial photographic interpreter. The releve procedure was not used as the basis for mapping.

Based on vegetation characteristics observed in the field or from the imagery, field workers located areas that were representative of creek reaches. Vegetation was sampled in a circle with its center point in the middle of the stream channel and an estimated circumference of 30 meters. The relative dominance of a species was then assessed and assigned a value on a scale of one (lowest) to five (highest). For example, if an area were primarily (90%) cottonwood, cottonwood would be given a value of five (5) on the releve form indicating that it is dominant. If two species were found to have equal representation then they would both be given values of four (4) representing codominance. In this manner, the relative abundance of different species were recorded and used later for delineating the riparian vegetation communities.

Global Positioning System (GPS) points were taken at the center point of each releve survey location using the Trimble GeoExplorerII and submitted to park personnel for correction. Supplemental information collected consisted of visual estimation of tree and shrub height, tree and shrub cover, herbaceous cover (forbs and graminoids), and ground cover. Only the maximum height for trees and shrubs within the releve were recorded. (Note: For points 26, 27, & 29, formal releve sheets were not done, these points were used to document the vegetation communities for verification and to locate important hydrological areas).

Based on the dominant or co-dominant species present stream reaches were assigned to a Series or Association level according to the vegetation classification system developed by Brown, Lowe, and Pase (Brown 1994). The classification system distinguishes vegetation by climatic zones based on elevation. Therefore, vegetation found in elevations higher than 1000 m (3281 ft) were placed within the Warm-Temperate climatic zone and those found below 1000 m (3281 ft) were placed within the Tropical-Subtropical climatic zone. When a riparian species (e.g., *Populus fremontii*) was dominant (releve code = 5), the classification was assigned based on that species type (e.g., *Populus fremontii* association). If the riparian species present in an area exhibited co-dominance or associations of three or more different species existed, then a classification found within the Mixed Broadleaf or Narrowleaf Series was used.



### Riparian Coverage Creation

The DOQQ's were used as the primary source to digitize riparian vegetation. Riparian areas were initially located based on a digital dataset obtained from Arizona Land Resource Information System (ALRIS). This dataset, an Arc/Info line coverage created in the fall of 1988 from U.S. Geological Survey's 1:100000 scale Digital Line Graphs (DLG), depicts linear hydrologic features (e.g., streams and rivers) in the state of Arizona. The coverage was modified by clipping the features to show the streams below 1219 m (4000 ft) in elevation. The clipped hydrological coverage was superimposed on the DOQQ's, and on-screen digitizing was performed using Arc/Info's© Arcedit module to create polygons of the vegetation along the stream corridors. A fuzzy tolerance of 1 m was used throughout the digitizing process and all polygons were checked for connectivity and continuity. Line coverages were not created for this project.

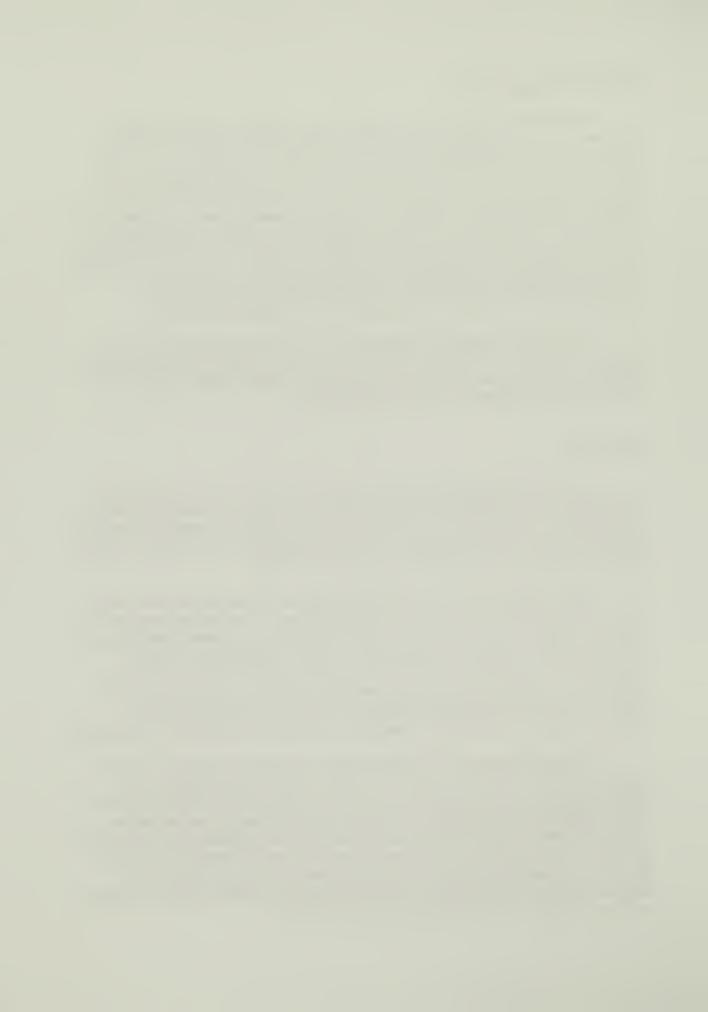
The minimum mapping resolution used in this project was approximately one hectare. In other words, no attempt was made to map patches less then a hectare, such as individual trees. Nor were within channel string communities mapped since they were difficult to see and delineate on the aerial photography.

#### RESULTS

A total of 29 field survey points were sampled and an Arc/Info point coverage was created using the GPS points obtained at each survey point. Each survey point has a site ID attribute that is linked to an ArcView data table. This table contains the type(s) of vegetation found at the site along with its associated prominence (reldom.dbf). Summary information collected at each survey point is found in Table 2.

Eleven different Brown, Lowe and Pace vegetation types were identified within Saguaro National Park East: nine vegetation associations and two vegetation series. The two series, Mixed Narrowleaf Series and Mixed Scrub Series represent vegetation types that were difficult to classify to the species level based on interpretation of aerial photography. This was especially true for the mixed scrub series where association is based no only on scrub species, but also forb and grass species. Appendix E lists the Brown Lowe and Pace class types identified for riparian areas located in Saguaro National Park East and describes the vegetation and climatic characteristics for each type.

The riparian dataset is an Arc/Info polygon coverage representing the riparian habitats found below 1219 m (4000 ft) of elevation in Saguaro National Park East. Eighty-four separate riparian vegetation patches (polygons) were identified and mapped using the DOQQs and videography. The map projection is North American Datum (NAD) 1927 with a Universal Transverse Mercator (UTM) coordinate system. Table 3 is a summary of the Brown, Lowe and Pace classes, the number of polygons coded with that class type, and the amount of area associated with each class. Portions of the Arc/Info coverages for the Tanque Verde Creek tributaries and Rincon Creek tributaries are shown in Figures 16 and 15 (main report), respectively.



Date	07/01/1999	07/01/1999	04/01/1088	07/05/1999	07/05/1999	07/05/1999	04/02/1999	07/05/1999	07/20/1999	07/20/1999	07/20/1999	07/20/1999	07/20/1999	07/20/1999	07/21/1999
Bare Grd. Cover(%)	5-15								30-50 (Rock)	15-30 (Rock)	30-50 (Rock)	50-70 (Rock)	50-70 (Rock)	15-30 (Rock)	15-30 (Rock)
Litter Cover(%)	1-5	5-15	5-15	15-30	30-50	15-30	50-70	50-70	1-5	5-15	5-15	5-15	5-15	5-15	5-15
Shrub Cover(%)	30-50	5-15	30-50	30-50	20-20	50-70	50-70	30-50	30-50	30-50	30-50	30-50	50-70	30-50	50-70
Max Shrub Height(m)	2	2	2	2	2	2	2	2	2	2.5	2.5	2.5	2	2	2.5
Tree Cover (%)	n/a	50-70	30-50	50-70	50-70	50-70	06-08	90-70	30-50	5-15	30-50	50-70	5-15	15-30	30-50
Max Tree Height(m)	n/a	~	6.5	4	5	6	7	12	9	4	9	v	4	4	12
Video	6:30:50	6:30:59	6:30:53	6:30:51	6:30:46	6:30:47	6:30:41	6:30:33	None	None	None	None	6:12:38	6:12:40	7:24:05
BLP	233.211	223.223	224.521	224.521	224.521	224.521	224.521	224.521	223.212	233.211	233.21	223.225	None	234.71	223.221
Dominant/Codominant	Carnegica gigantea, acacia greggi, parkinsonia aculeata	Lysiloma watoni, Fraxinus velutina	Fraxinus veluntina, Prosopis velutina		Prosopis velutina	Prosopis velutina	Fraxinus veluntina, Prosopis velutina	Prosopis velutina, wsome very large Populus fremontii	Juniperus monosperma, Populus fremontii	Associations of Cephalanthus occidentalis, P. fremontii, A. greggi, B. sarothroides, P. velutina	Cephalanthus occidentalis, Salix gooddingii, Populus fremontii, Juglans major	Juglans major, Prosopis velutina	Prosopis velutina	Populus fremontii, Prosopis velutina	Associations of P. fremontii, A. greggi, P. wrightii, C. pallida, B. sarothroides, F. Velutina
(m)	963	957	950	926	617	914	806	668	1195	1158	1189	1207	1204	1183	1036
Rel_ID Location Elev. Dominant/(m)	Box Canyon	Box Canyon	Box Canyon	Box Canyon	Box Canyon	Box Canyon	Box Canyon	Box Canyon	Tanque Verde Trib., off Douglas Springs trail	Tanque Verde Trib., off Douglas Springs trail	Tanque Verde Trib., off Douglas Springs trail	Tanque Verde Trib, just downstream from Briadal Wreath Falls	Tanque Verde Trib., Off 3-tanks trail	Tanque Verde Trib., Off 3-tanks trail	Rincon Creek, above private area
Rel_ID	-	2	6	4	- 2	9	7	∞	6	10	=	12	13	14	15



Table 2: Data from the Releve Survey Points, continued

Date		07/21/1999	07/21/1999	07/23/1999	07/23/1999	07/23/1999	07/27/1999	07/27/1999	07/29/1999	07/29/1999	12/17/1999	12/21/1999	12/21/1999	12/21/1999	12/21/1999
Bare Grd	Cover(%)	5-15 (Rock)	15-30 (Rock)	30-50 (Rock)	50-70 (Rock)	30-50 (Rock)	30-50 (Sand)	30-50 (Sand)	30-50 (Rock)	15-30 (Rock)	30-50 (Rock)	n/a	n/a	15-30 (Rock)	n/a
Litter	Cover(%)	15-30	5-15	30-50	15-30	15-30	5-15	5-15	5-15	5-15	1-5	n/a	n/a	1-5	n/a
Shrub	Cover(%)	50-70	30-50	30-50	30-50	20-20	02-05	02-05	20-70	20-70	50-70	n/a	n/a	20-20	n/a
Max Shrub	Height(m)	2.5	2.5	2.5	2.5	2.5	2	2.5	2.5	2.5	2	n/a	n/a	2	n/a
Tree	Cover (%)	06-08	50-70	50-70	50-70	30-50	15-30	15-30	n/a	50-70	1-5	n/a	n/a	15-30	n/a
Max Tree	Height(m)	14	15	13	12	14	\$	9	n/a	9	S	n/a	n/a	3.5	n/a
Video	Time	7:28:57	7:32:01	7:05:46	7:27:41	7:05:38	90:38:3	5:48:07	5:46:25	6:46:21	6:11:18	7:30:43	7:31:49	7:13:28	6:56:51
BLP	Class	223.221	223.221	223.221	223.221	223.211	234.71	234.71	234.71	224.522	234.71	233.21	233.21	233.21	223.221
Rel ID   Location   Elev.   Dominant/Codominant		Prosopis velutina, Fraxinus velutina	Fraxinus veluntina, Platanus wrightii	Quercus oblongifolia, Fraxinus velutina, Salix gooddingii	Quercus oblongifolia, Platanus wrightii	Prosopis velutina, Salix gooddingii	Prosopis velutina, Acacia greggi	Prosopis velutina, Acacia greggi	Acacia angustifolia	Prosopis velutina	Prosopis velutina, Carnegia gigantea, Acacia greggii	Celtis reticulata, Prosopis velutina	Celtis reticulata, Baccharis salicifolia	Baccharis salicifolia	P. fremonti, P. wrightii, F. velutina
Elev.	(m)	1027	1021	1055	1901	1021	914	098	972	963	096	1000	1000	1020	086
Location		Downstream of Rel. 15	Downstream of Rel.	Chimenea Creek, upstream of ranger station	Chimenea Creek, Upstream of Rel. 18	Chimenea Creek, downstream of Rel. 18	Off Cactus Forest Trail	Off Cactus Forest Trail	Off Loop Rd., near Javalina Picnic area	Downstream of Rel. 23	Tanque Verde Trib., off Carillo Trail	Rincon Creek Trib.	Rincon Creek	Medrona Creek	Chimenea Creek, downstream of Rel. 20
Rel ID	ı	16	17	18	19	20	21	22	23	24	25	56	27	28	29



The riparian dataset is an Arc/Info polygon coverage representing the riparian habitats found below 1219 m (4000 ft) of elevation in Saguaro National Park East. Eighty-four separate riparian vegetation patches (polygons) were identified and mapped using the DOQQs and videography. The map projection is North American Datum (NAD) 1927 with a Universal Transverse Mercator (UTM) coordinate system. Table 3 is a summary of the Brown, Lowe and Pace classes, the number of polygons coded with that class type, and the amount of area associated with each class. Portions of the Arc/Info coverages for the Tanque Verde Creek tributaries and Rincon Creek tributaries are shown in Figures 16 and 15 (main report), respectively.

As expected the most common riparian vegetation types where associated with the communities dominated or co-dominated by mesquite. The *Prosopis velutina* Association and *Prosopis velutina*-mixed short tree Association represent 40% of the total riparian area mapped, with mixed scrub series representing another 25% of the area (Table 3). In contrast, vegetation communities dominated or co-dominated by cottonwood represented less then 20% of the mapped riparian areas. Table 4 summarizes the deliverables generated from the riparian mapping effort.

Table 3: Results from Riparian Mapping in Saguaro National Park

Vegetation Type	BLP Code	Number of	Area in	Percent of
		Polygons	Square Meters	Total Area
Populus fremonti-Salix spp. Association	223.211	1	33,348	0.39
Populus fremonti Association	223.212	2	70,691	0.83
Platanus wrightii-Fraxinus velutina-	223.221	5	1,263,198	14.82
Populus fremonti-mixed deciduous				
Association				
Fraxinus velutina Association	223.223	4	248,867	2.92
Juglans major Association	223.225	1	34,489	0.40
Prosopis velutina Association	224.521	7	1,865,023	21.89
Prosopis velutina-mixed short tree	224.522	22	1,572,991	18.46
Association				
Populus fremonti-Salix goodingii	224.531	2	10,543	0.12
Association				
Mixed Narrowleaf Series	233.21	5	592,055	6.95
Cephalanthus occidentalis-Baccharis	233.211	6	330,113	3.87
glutinosa-mixed scrub Association				
Mixed Scrub Series	234.71	22	2,137,389	25.08
Stream Channel	n/a	3	294,646	3.46
Developed Area	n/a	4	67,696	0.79
Totals		84	8,521,049	100.00



Table 4: Project deliverables.

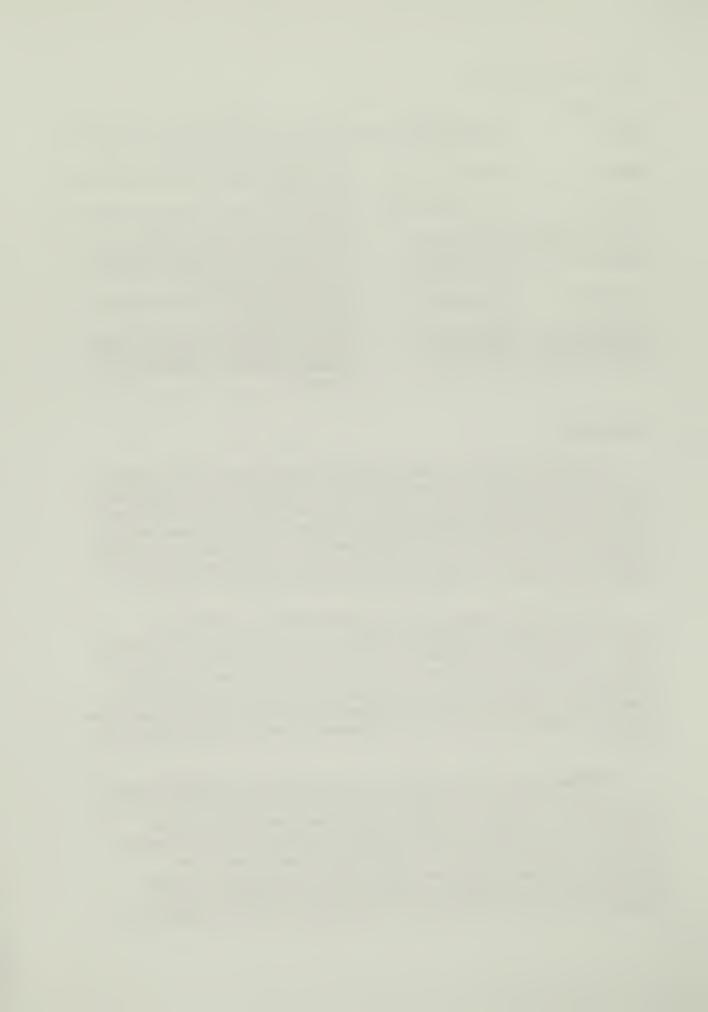
Name	Format	Description
Riparian	Arc/Info polygon coverage	Riparian vegetation under 4000 feet in elevation
Gpspts	Arc/Info point coverage	GPS points associated with vegetation survey points with releve sampling data
Ripphpts	Arc/Info point coverage	Points of flight lines for aerial video for the entire extent of flight
Ripphpts-clip	Arc/Info point coverage	Points of flight lines for aerial video clipped to a 200 meter buffer of riparian coverage
Aerial Video - oblique	High 8mm video	Oblique view of aerial footage of riparian areas
Aerial Video - vertical	High 8mm video	Vertical view of aerial footage of riparian areas
Reldom.dbf	Dbase database file	Table of the species found at each releve site and the associated dominance code
Vegcode.dbf	Dbase database file	Lookup table containing the BLP classification code and description
Ripmetadata.doc	Microsoft Word	Metadata documentation for riparian coverage
Gpsptsmetadata.doc	Microsoft Word	Metadata documentation for GPS point coverage
Ripphptsmetadata.doc	Microsoft Word	Metadata documentation for flight lines point coverage

#### **DISCUSSION**

The lack of information regarding classification of Arizona's riparian vegetation and the appropriate scale needed to realize the goals of this project made classification of riparian vegetation difficult. For example, some areas sampled exhibited co-dominance between riparian and non-riparian species (e.g., *Prosopis velutina* and *Acacia greggii*). The Brown, Lowe and Pace system does not currently have a classification for this type of vegetative community. When this situation occurred, classification was based on the dominant riparian species since the goal was to characterize the riparian vegetation.

An attempt was made to classify all vegetation to the Association level. However, it was difficult to determine dominance in the shrub communities using aerial imagery. As a result those communities were classified only to the Series level with the exception of Brown, Lowe and Pace *Cephalanthus occidentalis-Baccharis glutinosa*-mixed scrub Association that was keyed out from previous mapping work done in the expansion area (see Guertin, 1998). Delineating the shrub communities to the association level requires extensive field work over multiple seasons, and is beyond the scope of this project.

Although it was difficult to classify some vegetation based on available Brown, Lowe and Pace classifications, no attempt was made to create new classifications for this mapping effort. As a result, a classification that differentiates between traditional mesquite bosques and those areas exhibiting dominant mesquite trees, but lacking true bosque characteristics, have the same classification. Brown, Lowe and Pace classification documentation (Brown 1994) discusses the occurrences of mesquite bosques under the Sonoran Riparian Deciduous Forest and Woodlands, tropical-subtropical climatic zone, but an example of this vegetation type is not included in the



appendix of examples. Occurrences of mesquite bosques were found in tributaries to Tanque Verde Wash near the confluence with the major wash and along Rincon Creek at its intersection with Old Spanish Trail. Since a "mesquite bosque" vegetation type was not included in the Brown, Lowe and Pace system, these areas were coded with a type found under the Sonoran Oasis Forest and Woodlands, tropical-subtropical climatic zone (224.521). However, most vegetation communities coded with this type are not traditional bosques, i.e., they exhibit smaller trees with a more diverse understory. It is recommended that further analysis of the Brown, Lowe and Pace classification system be conducted to provide a classification for traditional mesquite bosques.

The results from this mapping effort can be used to assess the relative change to the riparian vegetation communities. For example, expansion of the *Prosopis velutina* dominated associations into areas currently supporting *Populus fremontii* dominated associations may indicate the system is becoming more xeric. However, the classification system used in this effort is based on vegetation composition, not vegetation structure and density. Often impacts to riparian systems are first observed through changes in vegetation structure, usually resulting from poor regeneration success. Since the riparian vegetation communities in Saguaro National Park, East are usually found in mixed aged stands it is difficult to determine regeneration success using photographic imagery. Field monitoring will be required to determine changes to vegetation structure and density. However, results from this study could be used to define baseline conditions and assess available wildlife habitat.

#### LITERATURE CITED

- Bennet, P. S., M.R. Kunzmann, and W.L. Halvorson. No Date. Manual for GAP program: Collecting vegetation classification data. National Biological Service Cooperative National Park Resources Studies Unit and University of Arizona Advanced Resources Technology. Tucson, AZ.
- Brown, D.E. (Ed.). 1994. Biotic communities Southwestern United States and Northwestern Mexico. Salt Lake City: University of Utah Press.
- Guertin, P.P. 1998. A vegetation and plant survey of the newly added lands of Saguaro National Park-Rincon Mountain District. Report submitted to the Saguaro National Park, Tucson, AZ.



## Appendix B

Precipitation Data

Tucson Magnetic Observatory

Santa Rita Experimental Range



ANNUAL		14.58	12.4	10.31	7.37	11.85	16.36	15.91	9.21	7.99	12.99	7.3	13.59	6.5	8.11	10.1	6.35	12	14.04	5.59	11.36	10.63	5.91	14.44	12.92	12.38		11.19	9.7	11.63	13.43	14.59	15.4	12.03	13.01	8.44
DEC	2.16	0.74	0.87	0.87	1.08	0.2	3.62	2.53	0.4	-	1.37	0.18	9.0	0.39	1.15	0.86	0	0.91	0.63	0.15	0.0	0.43	0.21	0.73	0	1.01	0.63	2.54	0.83	0.14	1.12	6.99	0.17	4.09	0.87	0.89
NOV	0.68	2.13	98.0	0.35	0.11	0.54	1.69	0.87	0	0	1.64	0	92.0	0.53	0.02	0.21	0	1.22	2.7	0.17	0	0.04	0	1.04	1.34	0.48	0.05	0.56	0.28	0.87	1.05	1.33	0.26	0.5	1.74	1.46
OCT	0	0	0.1	0.24	0.01	0.49	0.31	0.53	0.91	0.33	1.25	1.26	0.52	0.48	0.78	0.23	0.05	2.18	0	0	0	0.28	0.43	2.77	0.94	1.3	0.53	0.88	0.2	1.06	1.1	0.08	1.06	0.93	0.2	0.01
SEP		-	1.05	0.58	0.43	1.27	1.75	1.64	1.72	1.1	1.05	0.13	2.4	1.68	1.12	3.96	0.51	0.36	0.31	0	5.06	0.07	0.17	0.3	0.33	0.38	0.83	98.0	2.43	1.04	2.29	9.0	3.8	0.48	90.0	0.42
AUG		3.73	4.59	2.76	1.65	1.69	3.64	98.0	1.46	1.73	2.96	2.52	3.63	2.13	1.17	0.54	0.35	2.53	3.87	0.74	1.17	2.16	1.69	2.88	1:1	3.91		1.92	1.1	2.02	4	2.11	3.22	1.37	3.63	1.71
JUL		2.17	1.69	2.49	0.58	5.17	0.67	2.77	0.57	0.42	1.69	1.23	2.94	0.61	1.59	1.5	2.17	1.16	1.9	5.06	3.63	4.77	1.09	92.0	3.07	4.45	0.85	2.82	2.52	1.88	1.74	1.15	1.51	2.84	1.75	1.68
NON		0	0.3	0.15	1.38	0	1.43	0	0	0.15	0.11	0	0	0.25	0.02	0.01	1.47	0	0.58	0.4	0.56	0.45	0.03	0.03	0.53	0.13	0.03	0	0	0	0	0.03	0.11	0.1	0	0
MAY		0.13	0	0.25	0.01	0	0.31	0.49	0	1.01	0.35	0	0	0	0	0	0.05	0.04	0.02	0	0.53	0.15	0	0.26	0.03	0	0.05	0	0	0	0	90.0	0.33	0.41	0.01	0.26
APR		0	0.05	0.03	0.1	0.2	0.37	1.02	1.46	0.04	0.63	0.14	0.11	0	0	0.39	0	1.64	1.19	0	0	0	0.4	0.35	1.24	0.27	0	0	0	0.45	0.74	0.47	0.23	9.0	1.13	0.11
MAR		1.37	0.74	0.87	0.77	0.54	0.03	1.26	0.39	1.25	0.49	0.64	0.51	0.29	0.87	0.4	0.25	0.23	2.34	1.07	1.93	0.03	0	1.35	2.62	0	0.33	0.41	0.45	8.0	0.73	0.37	0.19	0.48	1.88	0.3
FEB		2.01	-	0.21	0.72	1.45	1.78	2.14	1.82	0.46	1.07	0.52	0.13	0.04	1.39	0.26	1.25	0.21	0.17	0.97	0.57	0.28	0.75	0.81	1.72	0.48	0.49	0.04	0.37	2.02	0	69.0	2.36	0.07	1.19	0.54
JAN		0.13	0.115	0.151	0.053	0.03	920.0	0.18	0.048	0.049	0.038	0.068	0.199	0.01	0	0.174	0.025	0.152	0.033	0.003	0.084	0.197	0.114	0.316	0	0	0.274	0.116	0.151	0.135	0.065	0.069	0.216	0.016	0.053	0.106
YEAR	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969

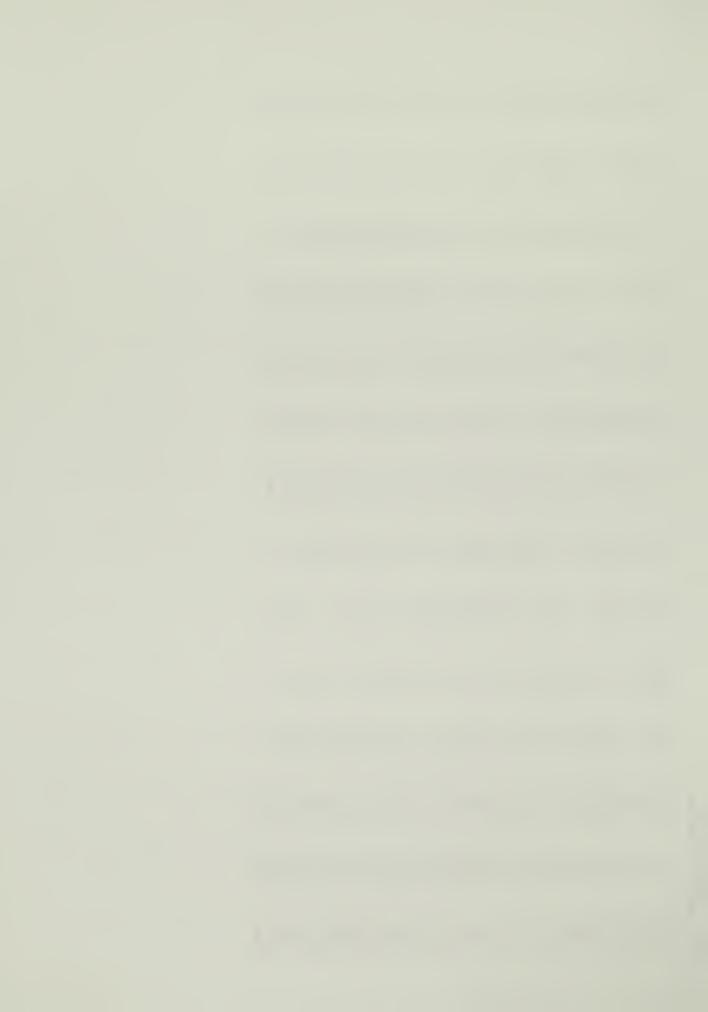


10.65	13.9	14.32	8.13	10.43	9.05	10.77	12.66	22.53	15.16	14.37	11.97	19.52	26.22	20.46	12.14	16.01	12.32	10.38	8.46	19.46	11.12	19.22	17.05
0.34	1.96	0.78	0	0.46	0.52	0.07	1.61	3.71	0.42	0.43	0	2.54	1.4	4.07	0.63	1.81	2.01	0.03	0.39	5.6	2.4	5.17	0.31
0	0.99	1.59	0.73	0.95	0.5	0.48	0.34	2.67	0.25	0	0.99	0.95	1.7	0.84	1.52	1.07	0.87	0.85	0.14	0.52	0.78	0	1.8
1.34	1.84	5.15	0	2.32	0.27	99.0	2.37	2.15	0.18	0.48	0.16	0	6.21	1.09	1.26	0.56	9.0	2.08	2.18	0.08	0.56	0.05	0.63
2.17	2.17	1.01	90.0	1.17	1.38	4.4	1.05	0.83	0.12	6.0	0.68	3.67	3.92	2.14	1.72	1.6	0.71	0.21	0.17	2.38	0.22	0.35	0.47
2.38	5.09	1.96	0.43	1.02	0.32	0.54	1.1	2.4	3.77	3.04	0.91	4.92	3.17	4.68	2.07	2.74	1.44	3.01	1.74	2.86	1.67	3.88	3.37
4.1	0.52	1.86	1.19	2.18	3.01	1.56	1.66	1.54	3.09	2.62	3.12	0.99	2.34	4.21	1.12	3.13	1.07	1.33	1.68	6.87	0.71	0.82	0.49
0.23	0	1.48	0.55	0.13	0	0	0.25	0.25	0.81	90.0	0.61	0.16	0	1.84	0	0.05	0.07	0.52	0.03	0.21	0.29	0	0
0.17	0	0.49	0.04	0	0	0.36	0.05	0.77	0.53	0.09	0.68	1.42	0.14	0.25	0	0.23	0.73	0	0.07	0	0	1.73	0.18
0.26	0.47	0	0.1	0	0.59	0.94	0.24	0.13	0.12	0.19	0.27	0.05	0.13	0.77	0.56	0.07	0.79	1.03	0	0.39	0	0.48	0
2.33	0	0	2.86	0.88	1.77	0.5	0.76	2.28	1.39	1.87	2.34	1.58	2.95	0	0.2	1.88	0.95	0.14	0.98	1.21	2.18	3.19	1.5
0.03	0.49	0	5.09	0.02	0.18	1.02	0	2.69	0.68	3.25	1.36	0.38	1.91	0	1.31	2.86	2.3	0.37	0.13	1.55	0.87	2.01	1.82
0	0.037	0	0.008	0.13	0.051	0.024	0.322	0.311	0.38	0.144	0.085	0.286	0.235	0.057	0.175	0.001	0.078	0.081	0.095	0.079	0.144	0.154	0.648
1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993

1.52

0.003

1994

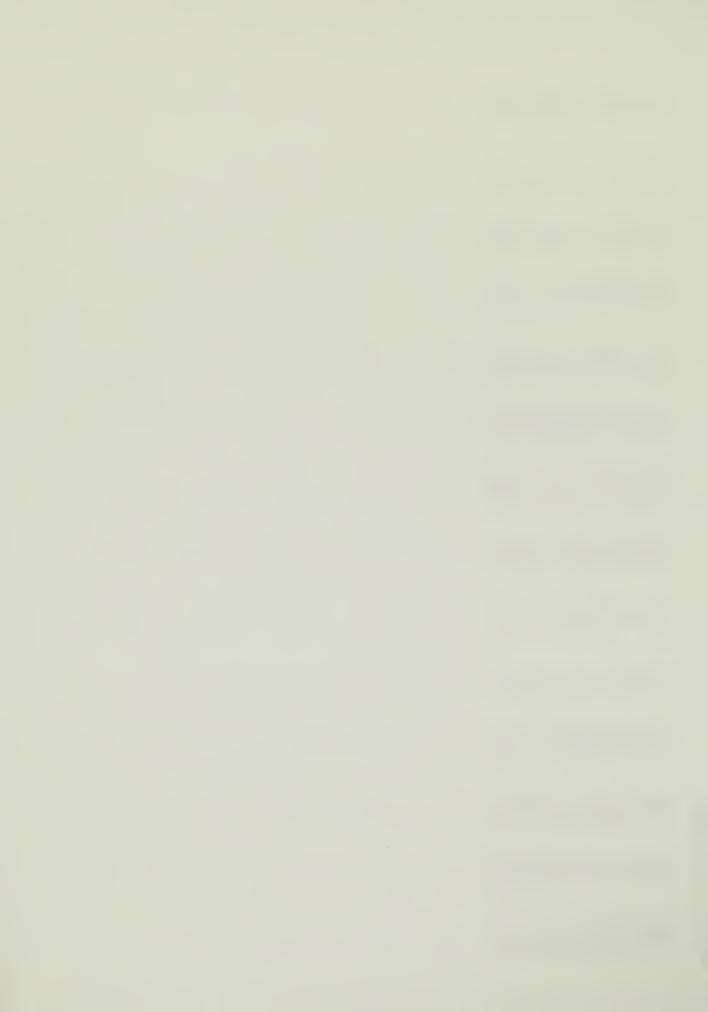


ANNUAL	0.09	22.85	21.6	11.94	22.54	21.88	10.51	20.37	26.25	24.55	0.09	25.19	15.55	20.26	25.13	25.04	23.69	27.51	16.36	16.33	0.09	24.36	0.09	17.27	23.29	18.73	24.31	20.36	0.09	19.36	0.09	0.09	0.09	39.63	34.5	28.42
DEC	0	2.92	1.19	0.1	0.18	0.29	0.95	0.78	0	3.21		3.04	2.65	1.25	2.18	9.13	0.47	8.49	1.72	0.78	0.12	4.8		0	0.35	6.0	0.53	1.55	4.8	0.36	0.28	0		0.84	7.29	0.5
NOV	0	1.28	3.42	0.16	0	0.01	0.05	0.54	6.0	1.1	0	6.0	0.57	3.89	1.23	1.15	1.18	1.33	1.33	1.3	9	1.68	1.56	-	0.34	1.59	0.91	0.45	4.36	0.62	0		2.74	2.61	0.83	1.96
OCT	0	2.57	0	0.18	0.37	0.78	0.78	2.91	0.61	2.4	2.07	3.69	0.09	99.0	1.37	0	0.43	1.	0.15	0.03	0.47	2.66	5.64	0	3.88	0	3.08	4.1	3.36	0.3		1.82	0	5.07	1.63	4.57
SEP	0.48	1.23	0.97	0	1.87	0.52	0.3	0	2.4	0.13	2.49	3.89	2.16	1.86	5.89	1.78	4.79	2.49	0	1.83	3.76	4.28	1.18	0.15	1.2	2.67	3.4	1.92	2.76	1.51	4.39	2.35	3.33	8.31	3.95	3.08
AUG	1.39	4.67	4.7	1.82	6.39	11.43	1.63	4.89	6.73	4.66	1.77	8.07	1.19	4.64	4.57	2.48	6.07	4.19	3.22	4.31	4.67	5.65	2.01	0.91	3.75	2.76	1.93	3.02	3.18	4.87	3.25	1.33	4.97	7.47	8.9	2.61
JOL	9.58	2.81	1.35	5.73	5.82	4.47	3.13	3.83	6.48	6.74	2.53	2.92	3.13	4.03	79.7	5.12	4.63	5.48	5.33	4.68	3.82	2.56	5.04	4.22	10.06	5.32	9.21	3.1	5.09	2.31	5.93	99.9	4.1	3.32	7.45	8.11
SUN	0.62	0	0.97	0.36	92.0	0	0.19	1.06	2.14	4.43	0.3	6.0	0.41	0	0.19	0.7	0.3	1.68	0	0.05	0.65	0.04	1.7	1.08	0	0	0.3	1.08	0.41	0.89	9.4	1.2	0.27	0	1.96	0.08
MAY	0.2	0.08	0	0.18	98.0	0	0	0.54	0.02	0	0	0	0	0.01	0	0	0.01	0.55	0	0.34	0	0.04	0.15	0	0	0	0.17	0.1	0.18	0.65	0.05	96.0		0.35	0.36	0.01
APR		3.14	2.85	0.38	0	0	0.36	0.48	6.0	0.25	0	0	0	0.82	0.54	0.89	0	0.89	0.39	0	0.28	0.91	0	0	0	1.39	1.52	0.5	0.15	0	0.11	0.5		1.15	1.72	1.5
MAR		0.25	4.32	0.93	3.91	0	0	1.26	4.09	0	0.35	0.58	1.03	0.85	1.18	0.62	0.1	0.88	1.85	98.0	2.34	0	0.01	5.21	0.88	2.68	0.81	1.08	2.89	2.51	2.01	3.93		4.21	0	0.41
FEB		0.38	0.37	2.1	0.91	96.0	1.43	0.38	1.98	1.63	1.19	0.12	1.05	1.23	0.24	1.98	2.86	0.33	1.81	<del>1</del> .	0.45	1.74	0	က	0.02	0.12	2.02	0.28	3.19	0.81	3.94	0.74		2.91	0	1.75
JAN		3.52	1.46	0	1.47	3.4	1.69	3.7	0	0	3.82	1.08	3.27	_	0.07	1.19	2.85	0.1	0.56	0.35	0	0	0	1.7	2.81	1.3	0.43	3.18	10	4.53	1.74		96.0	3.39	2.51	3.84
	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985



Santa Rita Experimental Range Monthly precipitation (inches)

19.63	24.7	29.92	16.46	31.34	22.24	27.94	24.49	24.82	13.44	15.31
2.21	3.38	0.74	0.79	2.41	3.95	5.94	0.47	4.93	0.84	0
0.67	0.83	0.79	0.18	0.99	1.25	90.0	1.98	3.95	0.88	0.28
0.78	0.79	5.45	4.16	0.38	0.75	0.07	1.26	99.0	0.65	1.88
0.98	2.07	0.3	99.0	3.85	1.24	1.46	8.0	3.62	1.22	1.43
5.22	5.39	8.02	4.15	3.94	4.92	5.59	6.28	4.45	2.55	5.41
3.65	4.29	7.54	1.43	11.15	1.18	5.29	4.18	1.42	1.76	3.88
0.85	0.04	0.35	0.32	3.3	0.97	0.01	0	0.53	0	0.55
0.51	1.4	0	0.25	0.16	0	1.65	99.0	0.28	0.15	0
0	1.79	2.87	0	0.21	0	0.36	0	0.45	0.63	0
1.61	0.47	0.49	1.75	1.06	3.82	4.47	1.9	2.71	0.94	0.39
2.38	2.68	1.18	0.56	5.6	2.36	-	2.25	1.44	2.21	1.26
0.77	1.57	2.19	2.21	1.29	8.	2.04	4.71	0.38	1.61	0.23
1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996



# Appendix C

**Streamflow Data** 

**Rincon Creek Gauging Station** 



1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0.4	0.4	0.4	0.5	0.5	0.4	0.4	9.0	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	1.2	-	6.0	0.7	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.4	-	9.0	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
1963	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	6.0
1958	0	0	0	0	0	16	7.4	1.6	0.1	0	0	0	0	0	0	0	0	0	0	0	225	22	6.5	4.2	2.7	7	1.3	8.0	9.0	4.0	0.3
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0.1	0.2	0.4	7.5	0.4	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1954	0	0	0	0	0	0	0	က	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-0ct	2-Oct	3-Oct	4-0ct	5-Oct	6-Oct	7-Oct	8-Oct	9-Oct	10-Oct	11-Oct	12-Oct	13-Oct	14-Oct	15-Oct	16-Oct	17-Oct	18-Oct	19-Oct	20-Oct	21-Oct	22-Oct	23-Oct	24-Oct	25-Oct	26-Oct	27-Oct	28-Oct	29-Oct	30-Oct	31-Oct



1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	o 0	0	0	0	0.04	0.04	0.03	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0.21	0.15	0.11	0.09	0.07	0.07	90.0	0.05	90.0	90.0	0.07	0.07	0.07	0.07	90.0	90.0	90.0	90.0	0.05	90.0	0.07	90.0	0.05	0.04	90.0	0.04	0.04	0.05	90.0	0.04
1989																														
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0.04	0	0	0.04	0.03	0	0	0	0	0	0	0	0	0	0.09	396	252	30	12	7.1	4.4	5.9	5.5	3.8	2.8	2.1	1.7	1.5
1971	4 5	8.7	6.3	4.4	3.2	2.7	2.2	1.9	<del>1</del> .8	<del>1</del> .8	1.7	1.8	1.8	1.9	2.1	78	37	27	21	21	23	19	19	38	34	16	ဖ	2.1	1.8	1.5
1970	0.03	0.12	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	o c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	<b>.</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	5 - - - - - - - - - - - - - - - - - - -	3-0 g	4-0ct	5-Oct	6-Oct	7-Oct	8-Oct	9-Oct	10-Oct	11-0ct	12-Oct	13-Oct	14-Oct	15-Oct	16-Oct	17-Oct	18-Oct	19-Oct	20-Oct	21-Oct	22-Oct	23-Oct	24-Oct	25-Oct	26-Oct	27-Oct	28-Oct	29-Oct	30-Oct	31-Oct



1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0.2	56	7.7	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0
1958	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.4	4	6.6	16	7	10	8.6	8.9	5.9	2	4.2	3.6
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.2	4.2	3.3	5.6	2.1	1.7	1.5	1.2	-	8.0	9.0	0.5	0.4	0.3
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-Nov	2-Nov	3-Nov	4-Nov	5-Nov	6-Nov	7-Nov	8-Nov	9-Nov	10-Nov	11-Nov	12-Nov	13-Nov	14-Nov	15-Nov	16-Nov	17-Nov	18-Nov	19-Nov	20-Nov	21-Nov	22-Nov	23-Nov	24-Nov	25-Nov	26-Nov	27-Nov	28-Nov	29-Nov	30-Nov



1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	89	354	81	19	6.5	3.1	9.1	0.97	0.63	0.51	0.45	0.41	0.39	0.36	0.32	0.31	0.28	0.29	0.28	0.28
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	1.2	2	3.9	3.4	3.1	2.2	1.4	6.	2.7	9.1	0.99	0.72	0.55	0.49	0.43
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0.04	0.09	0.04	0.04	0.04	0.04	0.07	90.0	90.0	0.09	0.07	0.08	0.07	90.0	90.0	0.07	0.07	0.09	0.08	0.09	0.11	0.14	0.12	0.18	0.2	0.17	0.05	0.04	0.05	0.04
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	4.	4.	1.3	1.2	1.2	<del>[</del> -	<del>-</del> -	_	_	_	_	<del>-</del> -	_	-	-	1:	6.2	13	=	8.7	7.3	5.9	5.2	5.4	4.8	4.2	3.6	2.8	2.3	1.9
1971	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.2	1.2	1.2	1.2	1.2	1.	0.94	0.99	13	17	12	7	6.5	ထ	8.1	6.2	4.7	3.1	2.3	7	1.7	1.6	1.9
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0.41	0	0	0	0	0	0.67	2.9	0.14	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-Nov	2-Nov	3-Nov	4-Nov	5-Nov	9-Nov	7-Nov	8-Nov	9-Nov	10-Nov	11-Nov	12-Nov	13-Nov	14-Nov	15-Nov	16-Nov	17-Nov	18-Nov	19-Nov	20-Nov	21-Nov	22-Nov	23-Nov	24-Nov	25-Nov	26-Nov	27-Nov	28-Nov	29-Nov	30-Nov



1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.32	0.34	0.33	3.8	33	415	06	40	33	35	40	35	28	22	18	18	15
1966	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0.1	0	0	0	0
1965	0	0	0	0	0	0	0	0	12	405	374	74	46	48	22	51	20	20	28	28	22	977	658	136	06	77	72	89	99	251	252
1964	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0.4	0.4	0.4	0.4	0.4	0.2	4.0	0.4	1.5	2.7	9.6	9.5	9.5	10	30	104	29	39	34	33	34	53	56	23	21	21	18	16	14	13	12
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0.1	3.3	2.8	2.3	2.3	2.2	2.2	7	7	<del>7</del> .	<del>7</del> 8.	9.	1.6	9.	4.9	53	44	24	15	=	8.6	=
1958	က	2.5	7	<del>1</del> .8	1.5	1.2	-	6.0	8.0	0.7	0.7	0.7	9.0	9.0	0.5	0.5	0.5	0.4	4.0	4.0	4.0	4.0	4.0	4.0	0.3	0.3	0.3	0.3	0.2	0.2	0.2
1957	0.2	0.2	0.2	0.2	2	8.1	3.3	2.7	5.6	2.5	2.4	2.4	2.2	2.1	7	1.9	<del>1</del> .8	1.7	9.1	4.1	1.3	1.2	1:	<del>-</del>	6.0	8.0	8.0	0.7	9.0	0.5	0.4
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
•	1-Dec	2-Dec	3-Dec	4-Dec	5-Dec	9-Dec	7-Dec	8-Dec	9-Dec	10-Dec	11-Dec	12-Dec	13-Dec	14-Dec	15-Dec	16-Dec	17-Dec	18-Dec	19-Dec	20-Dec	21-Dec	22-Dec	23-Dec	24-Dec	25-Dec	26-Dec	27-Dec	28-Dec	29-Dec	30-Dec	31-Dec



1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0.28	0.28	0.25	0.25	249	909	119	22	31	18	12	8.7	8.9	2	3.9	3.1	2.4	<del>1</del> .8	7:	1.3 E.	7:	6.0	-	<del>1</del> .8	2.3	32	64	42	33	31	31
1993	0.41	0.39	0.34	0.32	0.32	0.3	0.28	0.28	0.27	0.26	0.26	0.27	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.25	0.24	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.25	0.25
1992	0	0	0	19	259	38	13	77	28	52	18	17	12	7	4.9	3.5	5.6	7	2.7	3.5	5.9	2.7	2.5	2.4	ო	4.2	4.5	325	296	91	47
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	54	80	20	56	20	14	12	9	9.7	5.7	4.5	4.1	3.5
1990	0.04	0.04	0.04	90.0	0.07	0.05	90.0	0.07	60.0	0.09	0.09	60.0	0.16	0.11	60.0	0.13	90.0	0.04	0.04	0.08	0.29	0.21	0.14	0.13	0.13	0.12	0.1	28	77	22	32
		0																													
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	1.6	1.5	1.3	<del>-</del>	1.2	1.4	<del>-</del>	-	-	0.92	<del>-</del>	<del>-</del>	6.0	0.83	0.79	0.71	69.0	69.0	0.57	0.55	0.55	0.63	0.67	99.0	0.62	0.55	0.58	23	23	9.7	5.4
1971	1.8	1.7	1.6	3.6	4.5	5.6	5.2	7	12	13	14	9	12	56	56	32	19	18	53	27	28	43	11	29	35	37	49	25	21	15	7
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0.61	0.17	90.0	0	0	0	0	0	0	0.02	0.05	0.05	90.0	90.0	90.0	60.0	60.0	60.0	60.0	60.0	60.0	0.08	60.0	60.0	0.08	60.0	0.08
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-Dec	2-Dec	3-Dec	4-Dec	5-Dec	6-Dec	7-Dec	8-Dec	9-Dec	10-Dec	11-Dec	12-Dec	13-Dec	14-Dec	15-Dec	16-Dec	17-Dec	18-Dec	19-Dec	20-Dec	21-Dec	22-Dec	23-Dec	24-Dec	25-Dec	26-Dec	27-Dec	28-Dec	29-Dec	30-Dec	31-Dec



1967	15	12	6.6	<b>o</b>	7.8	7	6.8	13	15	4	18	13	7	10	9	9.4	8.7	7.6	6.1	2	4.6	4.3	4.9	5.5	6.1	6.4	ထ	14	22	17	13
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	134	80	62	20	44	4	36	34	30	27	27	25	22	20	19	19	19	27	42	40	40	34	30	25	22	21	22	33	33	32	35
1964	0.2	0.3	0.4	4.0	4.0	0.4	2.1	17	6.3	4.3	3.6	2.5	7	1.7	1.7	1.2	_	6.0	6.0	9.	4.3	3.9	3.6	3.9	3.6	3.2	2.8	2.5	7	1.5	1.5
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	4	က	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2
1961	12	7	9	12	Ξ	9	9	12	13	13	7.7	9.8	9.5	9	8.3	9.5	12	14	4	14	13	19	22	44	66	28	48	36	27	22	21
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	8	25	24	21	21	18	18	22	24	32	149	569	152	97	09	83	65	53	51	54	61	20	72	83	88	62	72	09	39	32	31
1958	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1957	0.4	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
1956	0	0	0	0	0	0	0	20	754	168	65	22	8.6	5.8	2.9	1.6	0.7	0.2	0.2	0.1	0.1	0.1	0	0	0	0	0	3.3	4.3	5.4	8.9
1955	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0.1	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-Jan	2-Jan	3-Jan	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan	11-Jan	12-Jan	13-Jan	14-Jan	15-Jan	16-Jan	17-Jan	18-Jan	19-Jan	20-Jan	21-Jan	22-Jan	23-Jan	24-Jan	25-Jan	26-Jan	27-Jan	28-Jan	29-Jan	30-Jan	31-Jan



1996	0	0.01	0.01	0	0.01	0.01	0	0	0	0	0	0.02	1.7	2.2	1.3	8.0	0.51	0.54	0.85	1.1	1.2	0.85	0.64	0.51	0.56	0.53	0.47	0.43	0.32	0.26
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	32	32	156	886	327	182	134	110	8	11	11	78	29	29	53	52	47	44	39	35	30	27	25	56	88	65	25	43	35	53
1993	0.27	0.27	0.27	0.28	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.2	0.2	0.2
1992	20	15	13	9	150	1330	1400	312	263	413	162	430	222	141	104	425	744	588	235	153	112	88	20	22	43	35	31	56	22	19
1991	2.3	<del>1</del> .9	က	24	77	26	4	33	27	32	87	43	31	23	15	12	10	8.4	9	20	16	13	9	9.6	9	=	=	9	6	7.8
1990	4	12	25	276	247	78	48	32	23	17	13	9	8.7	7.3	6.3	33	22	18	16	14	12	12	10	9.4	8.6	ω	7.3	6.5	5.3	4.7
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	36	18	<del>-</del> -	0	0	0	0	0	0.11	1.5	1.4	0.89	0.72	0.98	0.72	0.41	0.31	0.27	0.23	0.23	0.23	0.19	0.16
1972	3.6	3.3	2.9	5.6	2.2	7	1.8	1.7	1.7	1.6	1.5	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.5	1.3	1.5	1.3	1.2	1.1	1.2	1.2	1.1	_	1.1	2.8
1971	9.1	7.4	5.9	4.7	4.6	4	3.7	3.6	3.1	2.7	5.6	2.5	2.2	7	<del>6</del> .	1.7	1.7	1.6	1.5	1.4	1.4	1.3	1.2	1.	1.1	_	0.95	6.0	0.83	0.8
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0.08	90.0	90.0	90.0	0.08	0.08	0.07	0.07	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	0.08	80.0	0.07	90.0	0.05	0.05	90.0	90.0	0.08	0.08	0.07	90.0	0.05
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	92	23	8.4	3.5	2.1	1.7	1.6	25	16	8.4	5.3	10	7.7	5.6	3.8	2.6	2.1
1-Jan	2-Jan	3-Jan	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan	11-Jan	12-Jan	13-Jan	14-Jan	15-Jan	16-Jan	17-Jan	18-Jan	19-Jan	20-Jan	21-Jan	22-Jan	23-Jan	24-Jan	25-Jan	26-Jan	27-Jan	28-Jan	29-Jan	30-Jan	31-Jan



1967	12	10	8.9	8.6	7.7	7.3	6.8	7.3	10	107	99	684	208	101	4	56	20	16	4	13	12	7	တ	7.8	7.4	8.9	6.7	7.3	9
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1965	45	45	40	40	40	40	20	20	120	100	98	66	97	86	85	80	80	80	81	86	83	74	29	20	48	46	42	38	
1964	1.2	1.2	1.2	1.2	-	1.2	3.2	3.2	3.2	3.9	4.3	3.2	2.5	2.2	7	1.7	7	2.5	3.6	9.9	9.9	9.9	9.9	9.9	5.2	4.7	5.2	5.2	
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	3.2	7.5	7.7	4.6	2.5	1.5	1.2	6.0	4.0	9.9	114	126	52	24	19	18	4	13	15	18	21	25	21	18	16	15	13	1	
1961	18	17	16	16	16	15	15	13	15	21	27	56	56	71	20	17	4	9.5	6.5	4.2	3.8	4.2	3.8	3.6	<b>4</b> .8	6.1	9.5	5.9	
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1959	28	56	20	16	14	13	14	15	17	17	27	56	24	77	18	16	15	14	13	12	=	10	9.5	8.3	7.4	7.1	6.2	5.9	6.2
1958	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0
1957	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.4	0
1956	8.9	9.8	9	15	22	22	=	7.4	8.9	5.4	4.3	3.5	က	2.7	2.5	2.1	1.7	4.1	1.2	1.2	<del></del>	1.8	1.5	1.8	4.1	1.2	1.1	-	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-Feb	2-Feb	3-Feb	4-Feb	5-Feb	6-Feb	7-Feb	8-Feb	9-Feb	10-Feb	11-Feb	12-Feb	13-Feb	14-Feb	15-Feb	16-Feb	17-Feb	18-Feb	19-Feb	20-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb	28-Feb



1996	0.2	0.18	0.15	0.15	0.14	0.12	0.08	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.22	
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	27	31	34	30	27	24	21	18	18	19	16	13	154	121	767	231	123	84	61	45	36	35	35	52	21	16	7	12	
1993	0.2	0.18	0.18	0.18	0.18	0.18	0.19	0.44	0.28	0.26	0.27	0.28	0.28	0.32	0.32	0.33	0.32	0.33	0.47	0.63	0.58	0.57	0.52	0.48	0.46	0.45	0.41	0.41	
1992	17	15	13	=	9.4	8.3	7.7	9.7	37	11	46	34	28	20	139	83	89	71	168	201	110	92	29	20	43	36	30	39	
1991	6.9	7	9	12	9	8.5	16	104	64	40	46	25	336	142	73	20	38	27	51	16	13	12	<del>-</del>	<b>o</b>	7.5	9	4.9	4.3	3.9
1990	3.9	3.6	3.6	3.6	3.4	3.1	2.8	2.8	2.7	2.2	2.1	54	20	27	18	14	14	22	24	19	17	15	13	=	9.4	8.2	6.9	32	
1989	0	0	0	0	0	0	0	0	0	0	0	2.2	3.3	6.4	4.1	3.7	4	6.4	9	5.8	5.4	4.6	4.9	7.2	8.9	9.7	9	7.5	
1973	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.23	0.23	0.23	0.27	0.19	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.13	0.1	0.08	0.07	90.0	0.05	0.04	0.03	
1972	3.1	2.9	2.8	3.5	4.2	6.1	7	တ	6.9	5.2	4.4	4.4	9.9	9.6	=	8.5	7.5	6.9	5.8	12	541	858	250	129	74	52	40	31	
1971	0.78	92.0	0.75	0.91	0.98	0.63	0.62	0.55	0.55	0.55	0.55	0.55	0.49	0.48	0.47	0.46	0.46	0.46	0.42	0.45	0.46	0.46	0.46	0.46	0.42	0.42	0.42	0.42	0.42
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1969	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	
1968	<del>1</del> .8	1.7	1.6	4.	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.6	9.1	1.6	1.6	1.6	1.6	1.6	2.1	5.6	2.9	3.8	5	5.6	6.3	7	7.3	
	1-Feb	2-Feb	3-Feb	4-Feb	5-Feb	6-Feb	7-Feb	8-Feb	9-Feb	10-Feb	11-Feb	12-Feb	13-Feb	14-Feb	15-Feb	16-Feb	17-Feb	18-Feb	19-Feb	20-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb	28-Feb



1967	6.2	9.9	5.4	4.6	4.3	4	4.2	4.1	6.3	40	39	4	37	31	27	24	20	15	14	12	8.7	7.2	6.7	7.1	7.1	6.4	6.1	9	6.2	5.9	5.6
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	39	39	35	30	28	30	43	53	26	54	49	20	51	51	20	46	42	35	32	30	27	22	19	14	13	14	12	7	12	12	12
1964	4.7	4.3	3.2	2.5	2.2	1.7	1.5	1.2	-	1.2	<b>4</b> .8	9.9	9.9	7.1	9.9	8.4	9.9	6.1	6.1	6.1	9	9	2	2	4	4	က	က	7	7	7
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	8.9	7.1	5.6	5.1	2.8	3.2	2.8	2.5	2.2	<del>1</del> .8	<del>1</del> .8	1.6	1.2	-	-	-	4.	4.8	4.2	5.3	7.7	7	9	8.6	5.9	4.4	4.2	3.6	4	2	3.6
1961	11	12	12	7	13	13	14	14	18	16	15	13	15	14	13	13	Ξ	12	13	28	32	32	34	56	56	30	31	28	56	20	16
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	7.7	9.8	9	12	13	14	18	19	18	15	12	Ξ	9.5	9.5	œ	6.2	4.4	3.8	က	2.7	2.3	2.3	2.5	4.2	3.8	က	2.5	2.2	1.8	1.5	1.2
1958	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0.4	4.0	0.5	1.3	1.9	1.7	19	25	33	56	24	31	36	42	47	20	11	107	72	26	49	249	123	65	37	28	25	27	25	20	19
1956	6.0	9.0	8.0	9.0	0.5	0.5	0.5	0.5	0.5	0.7	6.0	0.7	8.0	9.0	9.0	9.0	0.5	0.5	6.0	7	17	16	Ξ	6.5	4.5	3.6	3.3	3.1	2.7	2.5	7
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.8	183	77	30	23	17	16	12	8.9	2.8
1952	0	0	0.4	7	12	16	19	32	30	20	15	9.5	9	9	2.4	2.2	7	1.9	1.6	4.1	6.0	9.0	9.0	0.5	0.5	0.3	4.0	0.4	0.3	0.2	0.2
	1-Mar	2-Mar	3-Mar	4-Mar	5-Mar	6-Mar	7-Mar	8-Mar	9-Mar	10-Mar	11-Mar	12-Mar	13-Mar	14-Mar	15-Mar	16-Mar	17-Mar	18-Mar	19-Mar	20-Mar	21-Mar	22-Mar	23-Mar	24-Mar	25-Mar	26-Mar	27-Mar	28-Mar	29-Mar	30-Mar	31-Mar



1996	Ξ	20	22	20	18	24	22	20	17	18	17	13	ω	5.2	3.7	2.7	7	4.	7:	0.91	0.75	0.56	0.42	0.33	0.25	0.2	0.17	0.15	0.15	0.15
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	9.7	8.3	6.9	6.2	327	147	20	47	32	24	21	16	13	9.9	6.7	9.9	5.6	4.7	4.1	3.4	က	5.6	2.3	2.1	<del>1</del> .9	<del>1</del> .8	1.7	1.5	1.4	1.3
1993	0.39	0.36	0.38	0.4	0.41	0.44	0.51	0.56	0.58	0.55	0.52	0.48	0.46	0.45	0.44	0.42	0.43	0.45	84	28	12	5.8	3.8	5.6	9	7	တ	œ	4.6	4.5
1992	29	63	62	23	45	39	34	53	24	21	18	15	13	7	7	9	9.3	8.8	9.7	9.9	6.1	5.5	2	4.4	4.3	12	Ξ	28	32	29
3.7	6.4	37	39	09	42	35	72	104	83	81	69	64	28	51	43	35	56	20	17	4	12	7	9	9.5	8.3	9.5	191	146	78	28
1990	299	93	89	09	29	47	33	56	21	21	17	4	7	8.2	6.6	7	9	10	8.6	23	42	88	102	92	89	72	20	89	72	65
1989																														0.65
1973	0.02	0.02	0.01	0.01	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	70	19	19	17	17	18	20	27	30	32	26	97	144	132	198	233	196	141	122	112	9/	99	61	22	46	65	53	65	72	72
1971	0.39	0.39	0.39	0.39	0.39	0.39	0.35	0.34	0.35	0.36	0.36	0.36	0.33	0.33	0.32	0.31	0.3	0.3	0.25	0.24	0.22	0.22	0.25	0.21	0.18	0.19	0.19	0.2	0.19	0.17
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	2.1	4.4	0.82	0.51	0.67	0.93	2.3	3.8	4.4	13	12	12	14	18	16	12	8.1	4.9	2.8	9.1	1.1	0.83	0.84	0.87	0.95	8.0	0.7	9.0	9.0	9.0
1968	2	4.1	2.9	2.3	2.3	2.9	2.3	2.1	2.1	2.1	1.9	1.9	1.9	5.6	5.6	5.9	3.2	3.8	4.7	4.7	5.3	6.3	10	ω	6.3	5.3	4.4	3.8	3.5	5.6
1-Mar	2-Mar	3-Mar	4-Mar	5-Mar	6-Mar	7-Mar	8-Mar	9-Mar	10-Mar	11-Mar	12-Mar	13-Mar	14-Mar	15-Mar	16-Mar	17-Mar	18-Mar	19-Mar	20-Mar	21-Mar	22-Mar	23-Mar	24-Mar	25-Mar	26-Mar	27-Mar	28-Mar	29-Mar	30-Mar	31-Mar



1967	5.1	5.6	တ	7.7	7.3	7.2	9.9	5.8	5.3	6.8	12	7.2	7.3	6.3	5.6	5	4.5	4	3.4	က	2.2	7	1.9	1.8	1.7	1.5	1.4	1.3	7:	<del>-</del> -
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	Ξ	Ξ	Ξ	7	တ	œ	7	ဖ	5	4.5	4	3.5	က	2.5	2.5	7	7	1.5	1.6	1.6	1.6	<del>1</del> .8	<del>1</del> .8	1.5	1.5	4.	1.3	1.2	1.2	1.1
1964	7	2.2	7	13	14	13	13	4	12	Ξ	9.7	8.4	7.1	9.9	4.3	3.6	2.8	2.2	7	1.7	-	6.0	9.0	9.0	4.0	4.0	4.0	0.3	0.2	0.2
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	2.7	<del>1</del> .8	5.	-	0.7	0.5	9.0	ე. შ	0.5	0.5	9.0	0.5	0.5	0.5	9.0	9.0	4.0	4.0	4.0	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
1961	15	13	13	12	=	Ξ	9.5	8.9	8.6	8.9	4	1.5	0.7	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	<del>-</del>	6.0	8.0	8.0	0.7	9.0	9.0	9.0	6.0	8.0	0.7	0.5	4.0	4.0	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	17	15	13	16	4	12	=	27	41	42	35	27	22	19	16	16	15	12	9.7	7.2	4.4	4.4	3.8	2.7	2.2	5.	<del>-</del>	8.0	0.7	9.0
1956	1.7	9.	<del>1</del> .3	1.2	6.0	8.0	0.7	9.0	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	6.0	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0
	1-Apr	2-Apr	3-Apr	4-Apr	5-Apr	6-Apr	7-Apr	8-Apr	9-Apr	10-Apr	11-Apr	12-Apr	13-Apr	14-Apr	15-Apr	16-Apr	17-Apr	18-Apr	19-Apr	20-Apr	21-Apr	22-Apr	23-Apr	24-Apr	25-Apr	26-Apr	27-Apr	28-Apr	29-Apr	30-Apr



1996	0.13	0.12	0.13	0.14	0.14	0.13	0.13	0.14	0.16	0.15	0.14	0.13	0.12	0.12	0.11	0.11	0.11	0.1	0.1	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.07	90.0	90.0	90.0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	1.2	<del>1.</del>	-	96.0	0.88	0.82	0.75	99.0	99.0	0.61	0.58	0.55	0.54	0.51	0.51	0.5	0.51	0.51	9.0	2.3	9	<del>-</del>	9.1	7.1	ς,	3.3	2.3	1.7	1.3	1.1
1993	3.4	2.5	<del>1</del> .8	4.	<del>[</del> :	0.89	92.0	0.67	9.0	0.53	0.46	0.45	0.44	0.39	0.35	0.31	0.29	0.27	0.25	0.24	0.22	0.2	0.19	0.18	0.18	0.18	0.18	0.18	0.17	0.16
1992	24	19	15	7	8.7	7	6.1	5.2	4.6	3.9	3.5	3.1	2.8	2.7	2.4	2.2	7	<del>1</del> .8	1.7	1.5	4.	<del>1</del> .3	<del>1.</del>	0.99	0.95	0.91	0.84	8.0	0.79	0.75
1991	51	73	53	44	37	28	22	17	4	7	9.5	9.7	6.3	5.2	4.2	3.6	က	2.5	1.9	1.7	1.4	7:	6.0	0.83	0.75	0.67	0.61	0.56	0.51	0.47
1990	71	20	22	52	48	42	36	27	20	15	12	9.3	9.7	9	2	4.2	3.6	3.2	2.8	2.4	7	<del>1</del> .8	9.1	1.3	_	96.0	0.91	0.87	0.82	0.8
1989	0.64	9.0	9.0	0.59	0.55	0.51	0.46	0.44	0.41	0.39	0.39	0.35	0.34	0.31	0.28	0.26	0.23	0.21	0.2	0.17	0.15	0.13	0.12	0.13	0.1	80.0	90.0	0.05	0.04	0.03
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	64	51	37	30	25	20	20	15	15	10	9	15	25	15	15	15	13	16	13	12	9	9.4	7	12	7	7	7	9	10	7.4
1971	0.17	0.17	0.16	0.16	0.13	0.13	0.13	0.12	0.11	0.09	0.08	0.07	90.0	0.04	0.05	0.04	0.03	0.02	0.01	0.01	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	9.0	9.0	9.0	9.0	9.0	9.0	0.65	0.58	0.58	0.5	0.47	0.46	0.42	9.4	0.39	0.36	0.36	0.33	0.33	0.31	0.27	0.27	0.26	0.26	0.23	0.23	0.26	0.24	0.25	0.23
1968	2.3	2.1	1.9	<del>7</del> .8	1.7	1.5	1.5	<del>1</del> .3	1.3	<del>-</del> -	1.1	_	96.0	0.82	0.78	0.78	0.71	0.7	0.63	0.62	0.53	0.52	0.46	0.46	0.42	0.41	0.36	0.36	0.36	0.34
	1-Apr	2-Apr	3-Apr	4-Apr	5-Apr	6-Apr	7-Apr	8-Apr	9-Apr	10-Apr	11-Apr	12-Apr	13-Apr	14-Apr	15-Apr	16-Apr	17-Apr	18-Apr	19-Apr	20-Apr	21-Apr	22-Apr	23-Apr	24-Apr	25-Apr	26-Apr	27-Apr	28-Apr	29-Apr	30-Apr



1967	<del>-</del>	_	0.87	0.83	0.83	0.75	0.73	0.65	0.62	0.61	0.54	0.53	0.48	0.46	0.41	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	<del>-</del> -	-	6.0	8.0	8.0	9.0	9.0	9.0	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1964	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0.5	0.5	4.0	0.4	0.4	0.3	0.3	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-May	2-May	3-May	4-May	5-May	6-May	7-May	8-May	9-May	10-May	11-May	12-May	13-May	14-May	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May	23-May	24-May	25-May	26-May	27-May	28-May	29-May	30-May	31-May



1996	0.05	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0.01	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0.97	0.87	0.77	0.7	0.65	0.64	99.0	0.64	0.63	0.57	0.53	0.47	0.45	0.41	0.39	0.37	98.0	0.34	0.33	0.31	0.29	0.27	0.26	0.25	0.24	0.23	0.22	0.2	0.19	0.18	0.17
1993	0.14	0.13	0.12	0.11	60.0	90.0	0.07	0.07	90.0	90.0	60.0	60.0	0.07	0.04	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0.64	9.0	0.58	0.52	0.58	0.21	0.38	0.44	0.3	0.18	0.2	0.18	0.18	0.14	0.05	90.0	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
1991	0.45	0.44	0.42	0.39	4.0	0.31	0.24	0.21	0.21	0.2	0.15	0.12	60.0	90.0	0.04	0.03	0.03	1.9	0.25	0.14	4.1	0.37	0.28	0.25	0.21	0.14	0.25	0.24	0.18	0.12	60.0
1990	0.77	0.7	99.0	0.63	0.62	0.58	0.56	0.54	0.52	0.49	0.48	0.47	0.44	0.42	0.39	0.37	0.31	0.23	0.22	0.18	0.15	0.13	0.1	80.0	90.0	0.04	0.03	0.02	0.01	0.01	0.01
1989	0.03	0.04	0.03	0.02	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	5.8	4.5	4	4	4.3	2	3.6	က	2.5	2.1	1.8	1.6	1.6	1.5	4.	1.3	1.3	1.2	-	0.93	6.0	0.87	0.81	0.78	0.79	0.71	0.73	69.0	0.59	0.57	0.46
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13	9.	5.6	2.8
1969	0.22	0.18	0.18	0.17	0.14	0.13	0.11	0.11	0.1	80.0	0.07	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0.34	0.27	0.25	0.21	0.26	0.24	0.21	0.17	0.14	0.07	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-May	2-May	3-May	4-May	5-May	6-May	7-May	8-May	9-May	10-May	11-May	12-May	13-May	14-May	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May	23-May	24-May	25-May	26-May	27-May	28-May	29-May	30-May	31-May



1967	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
•	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	e-Jun	1-Jun	8-Jun	9-Jun	10-Jun	11-Jun	12-Jun	13-Jun	14-Jun	15-Jun	16-Jun	17-Jun	18-Jun	19-Jun	20-Jun	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	29-Jun	30-Jun



1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0.16	0.15	0.14	0.13	0.12	0.11	0.1	0.1	0.09	0.08	0.07	0.07	90.0	0.05	0.03	0.03	0.03	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0.05	0.03	0.03	0.02	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0.01	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
_																													0	
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0.43	0.41	0.38	0.35	0.31	0.24	0.21	0.18	0.17	0.16	0.16	0.18	0.21	0.19	0.19	0.17	0.16	0.17	0.16	0.15	0.13	0.1	0.1	0.08	90.0	0.03	0.01	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	5.9	2.4	2.5	7	2.2	2.2	2.2	2.3	1.9	1.9	<del>1</del> .8	1.7	1.6	1.6	2.1	2.2	7	7	7	7	7	96.0	0.04	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	e-Jun	7-Jun	8-Jun	9-Jun	10-Jun	11-Jun	12-Jun	13-Jun	14-Jun	15-Jun	16-Jun	17-Jun	18-Jun	19-Jun	20-Jun	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	29-Jun	30-Jun



1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	3.8	0	0	0	0	0	0	0	5.5	<del>1</del> .3	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	9.4	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0.5	0.5	0	0	0	0	2.8	13
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0.2	0	0	0	2.4	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	က	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	က	0	0	0	0	0	0	0	0	0.3	0	1.5
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	179	15	6.7	1.2	0	0	0	9.6	8.4	154
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	5.2	17	09	18	1.3	0.1	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	4.6	7	0.1	0	0	0	0	0	0	0	0	7.5	59	24
	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	e-Jul	7-Jul	8-Jul	9-Jul	10-Jul	11-Jul	12-Jul	13-Jul	14-Jul	15-Jul	16-Jul	17-Jul	18-Jul	19-Jul	20-Jul	21-Jul	22-Jul	23-Jul	24-Jul	25-Jul	26-Jul	27-Jul	28-Jul	29-Jul	30-Jul	31-Jul



1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0.11	0.14	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0
1989	0	0	0	0	0	0	31	0.61	31	9	32	19	0.72	0.03	84	136	87	48	25	260	71	30	163								
1973	0	0	0	0	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0.02	0	0	0	3.3	9.4	14	7.1	4.2	1.5	0.46	0.16	0.11	90.0	0.03	0.01	0	0	0	0	0.07	0.03	0.02	0.02
1971	0	0	0	0	0	6.0	0	0	0	0	0	0	0	0	0	13	5.6	0	0	0	0	0	0	3.7	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.23	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0.18	0.04	0	0	0	0	7.8	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	lnC-9	1-Jul	8-Jul	InC-6	10-Jul	11-Jul	12-Jul	13-Jul	14-Jul	15-Jul	16-Jul	17-Jul	18-Jul	19-Jul	20-Jul	21-Jul	22-Jul	23-Jul	24-Jul	25-Jul	26-Jul	27-Jul	28-Jul	29-Jul	30-Jul	31-Jul



1967	2.2	98.0	8.6	18	3.8	-	0.71	3.4	92	9.8	3.1	1.3	0.58	0.33	0.2	0.14	0.12	0.1	0.2	7:	0.5	0.26	0.18	0.14	1.4	2.9	0.61	2.8	6.9	4.7
1966	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	4.0	0	0	0	0	0	27	22	53	19	7.1	3.1	1.3	2.2	4.6	7.8	65	28	9.4	5.6	8.9	2	4.5	2.9	9.	_	6.0	1.2
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.7	6.0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	2.1	0.2	0	0	0	0.2	7.3	2.5	1.7	0.7	0.5	0	0	0	0.5	0	0	1.8	4.7	1.2	0	0	0	7	22	4.1	1.2	0.2	0
1962	137	21	122	23	36	19	6.7	4.2	2.8	1.7	4.3	2.8	0.7	8.0	8.0	0.2	0.2	164	27	12	13	9.7	3.2	248	106	53	4	18	21	20
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	6.8	15	0.1	0	0.1	0	0	0	0	0	0	8.8	0	4	4.7	3.5	17	2.3	0.1	0	138	49	8.3	2.8	4.0	0	0	5.1	4.1	0.3
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	26 26	2.3	0	19	8.3	33	0	0.1	0	0	0	65	63	114	26	120	52	43	14	8.9	19	8.6	7.5	12	15	6.2	က	1.5	8.0	0.5
1957	0	3.4	0	0	48	34	14	1.8	0.5	0.1	0	0	0	0	-	23	-	0	0	0	19	20	38	21	5.8	4.0	0.2	0.1	0.1	0.1
1956	0.5	0	-	150	169	20	14	7	3.5	7	24	22	35	34	53	40	25	17	18	7.4	106	69	30	8.2	3.8	5.6	2.1	1.2	1.4	158
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	55	392	54	27	64	73	33	4	14	6.9	Ξ	317	151	87	42	29	30	33	135	29	48	42	110	43	30	18	Ξ	7.5	5.8	4.6
1953	0	5.6	17	8.9	5.3	4	4	2.5	3.2	7	16	2.2	0.7	1.6	0.5	2.5	1.8	395	208	101	34	39	21	9.5	4.1	1.5	0.5	0.5	0.4	0.4
1952	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	17	12	<del>1</del> .8	0.1	0
1-A110	2-Aug	3-Aug	4-Aug	5-Aug	6-Aug	7-Aug	8-Aug	9-Aug	10-Aug	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	31-Aug



1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	3.8	0.32	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.21	0	0	0	0	0	0	0	0.14	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0.07	0	0	0	0	0	0	0	0	0	0	0	0
1993																															
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0	0	0	0	3.1	32	23	474	202
1991																															
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989															110	65	35	18	9.6	9	3.7	2.3	4.	6.0	0.73	0.59	0.47	0.4	0.29	0.19	9.6
1973	20	9.7	<del>-</del> -	8.7	0.81	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0.02	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	6.4	<del>-</del> -	0	0	0	0	0	0	0	0	0	0	0	0	0.43	0	0	0	0	0
1970	0	0	0.46	0.05	0	0	0	0	0	2.1	0	0	0	0	0	0	0	16	634	138	199	106	56	6.7	3.7	6.	1.4	1.3	3.2	7	2.8
1969	56	<del>[.</del>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	22	<del>-</del>	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	21	18	7	2.2	0.61	0.04	0	0	0	0	0	0	0	0	_	0	0	0	0	0
	1-Aug	2-Aug	3-Aug	4-Aug	5-Aug	6-Aug	7-Aug	8-Aug	6-Aug	10-Aug	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	31-Aug



1967	2.6	1.2	89.	.41	.33	.28	.25	.22	.18	.12	90.0	.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
																								0						
1965 1	1.1	_	8.0	9.0	9.0	0.4	0.4	0	0	0	2.2	62	47	30	82	48	21	17	10	6.7	7.5	5.8	2	3.5	2.9	2.1	1.6	1.4	1.2	_
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	9.0	89	29	37	23	34	80	21	10	4.3	16	<del></del>	5.2	6.4	102	52	16	9.7	5.2	3.9	2.8	2
1962	27	16	20	75	23	12	8.4	2	3.2	7	<b>-</b>	0.7	9.0	9.0	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0
1960	0	0	0	0	0	0	0	48	4	4	1.7	5.2	4.3	2.1	1.3	-	0.7	0.5	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	4.0	4.0	0.3	0.2	0.1	0.1	0	0	0	0	9.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	262	35	8.2	4.5	3.4	2.7	2.1	<del>1</del> .9	1.5	<del>-</del> -	6.0	8.0	0.7	9.0	0.5	0.4	0.3	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	2.8	1.9	1.6	1.4	1.2	1.2	<del>-</del> -	<del>-</del> -	<del>1.</del>	6.0	8.0	9.0	0.5	0.5	0.4	0.4	4.0	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	4.0	0.3	4.0	4.0
1953	0.3	0.3	0.2	0.2	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-Sep	2-Sep	3-Sep	4-Sep	5-Sep	6-Sep	7-Sep	8-Sep	9-Sep	10-Sep	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep	21-Sep	22-Sep	23-Sep	24-Sep	25-Sep	26-Sep	27-Sep	28-Sep	29-Sep	30-Sep



1996	0	0	0	0	0	0	0	0	0	0	0.08	0	0.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0.15	0.03	0	13	9.6	1.3	0.09	0	0	2.2	5.6	1.5	0.3	0.05	0	0	0	0	0	0	0	0	0	0	0.27	0.01	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0.1	0
1993	0	0	92	20	4.3	1.5	0.52	0.19	0.11	0.08	31	59	5.4	2.3	<del>-</del> -	0.47	0.22	0.15	0.11	0.09	0.08	0.07	0.04	0.02	0	0	0	0	0	0
1992	72	28	12	5.8	3.1	1.8	0.97	0.58	0.18	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0	0	0
1991	0.5	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	27																													
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0.71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	7.8	15	6.3	3.1	1.9	1.2	0.85	9	7	1.6	1:1	0.73	69.0	0.62	0.53	0.5	124	34	54	9.4	3.3	<del>1</del> .4	0.84	0.61	0.44	0.29	0.21	0.16	15	30
1969	0	0	0	276	134	29	35	21	18	œ	4.4	3.2	5.6	1.9	4.1	0.72	0.37	0.2	0.1	0.1	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.03
1968	0	0	0	1.6	0	16	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-Sep	2-Sep	3-Sep	4-Sep	5-Sep	6-Sep	7-Sep	8-Sep	6-Sep	10-Sep	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep	21-Sep	22-Sep	23-Sep	24-Sep	25-Sep	26-Sep	27-Sep	28-Sep	29-Sep	30-Sep



# Appendix D

Metadata

## Metadata for Digital Orthophoto Quarter Quads

## **Greyscale DOQQ Metadata**

	,
Quarter Quad	URL
Tanque Verde Peak, (nw)	http://aria.arizona.edu/servlet/MetadataServlet?ID=368
Tanque Verde Peak, (ne)	http://aria.arizona.edu/servlet/MetadataServlet?ID=369
Tanque Verde Peak, (sw)	http://aria.arizona.edu/servlet/MetadataServlet?ID=371
Tanque Verde Peak, (se)	http://aria.arizona.edu/servlet/MetadataServlet?ID=370
Mica Mountain, (nw)	http://aria.arizona.edu/servlet/MetadataServlet?ID=352
Mica Mountain, (ne)	http://aria.arizona.edu/servlet/MetadataServlet?ID=353
Mica Mountain, (sw)	http://aria.arizona.edu/servlet/MetadataServlet?ID=355
Mica Mountain, (se)	http://aria.arizona.edu/servlet/MetadataServlet?ID=354



## Metadata for GPS Points - Arc/Info Coverage

Report Date: 01-Jan-2000

Metadata Data Set Name: gpspts

1 Identification Information

1.1 Citation Information:

8.1 Originator: Felicia M. Sirchia

8.2 Publication Date: 20000101

8.4 Title: GPS points of releve sample plots in

Saguaro National Park

8.6 Data Presentation Form: Digital (Arc/Info Format)

8.8.1 Publication Place: Tucson, Arizona
8.8.2 Publisher: University of Arizona

1.2 Description

1.2.1 Abstract:

Points were generated from a Trimble GeoExplorerII and are associated with releve sample plots. The releve's were conducted to collect data for riparian vegetation classification purposes.

1.2.2 Purpose:

To provide a digital and georeferenced record of sample points within the park.

1.3 Time Period Of Content

9.1 Single Date/Time:

9.1.1 Calendar Date: 1999

1.3.1 Currentness Reference:

Year data was collected.

1.4 Status

1.4.1 Progress: Completed
1.4.2 Maintenance and Update Frequency: Not Applicable

1.5 Geographic Extent

1.5.1 Description of Geographic Extent:

Saguaro National Park East Rincon Mountain District

1.6 Keywords

1.6.1.1 Theme Keyword Thesaurus: None 1.6.1.2 Theme Keyword: Point

1.6.1.2 Theme Keyword: Releve Points

1.6.2.1 Place Keyword Thesaurus: None 1.6.2.2 Place Keyword: Arizona

1.6.2.2 Place Keyword: Saguaro National Park

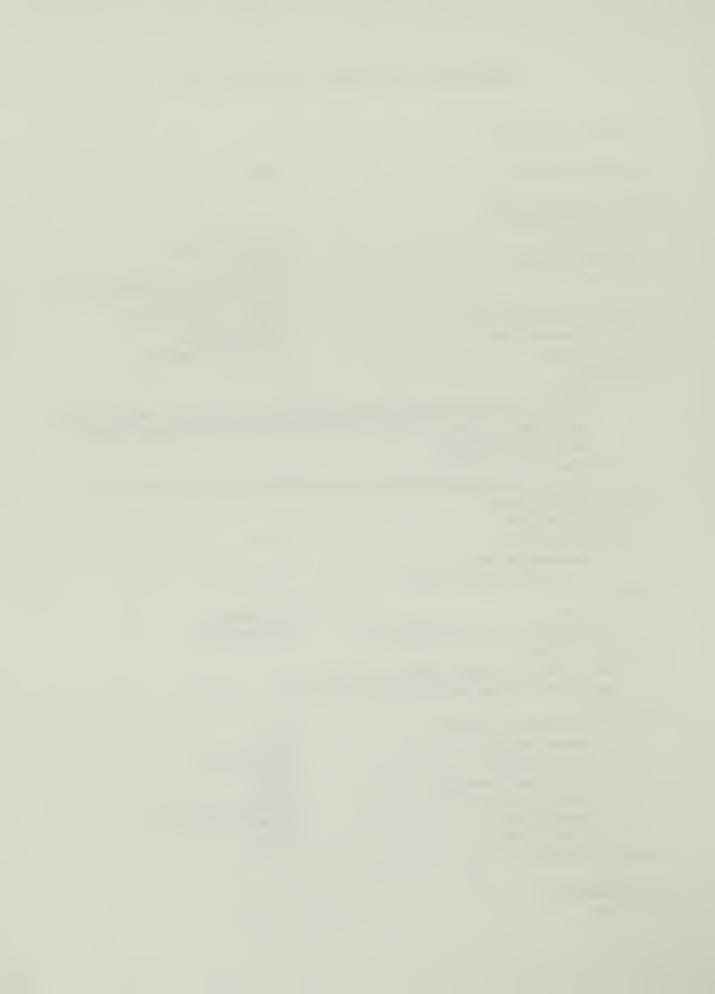
1.6.2.2 Place Keyword: Tucson

1.8 Access Constraints:

None

1.9 Use Constraints:

None



#### 1.10 Point of Contact

10.2 Contact Organization Primary

10.1.2 Contact Organization:

10.1.1 Contact Person:

10.3 Contact Position:

10.4 Contact Address

10.4.1 Address Type

10.4.2 Address:

10.4.3 City:

10.4.4 State or Province:

10.4.5 Postal Code:

10.4.6 Country:

10.5 Contact Voice Telephone:

10.7 Contact Facsimile Telephone:

10.8 Contact Electronic Mail Address:

10.9 Hours of Service:

University of Arizona Dr. Phil Guertin Associate Professor

Mailing and Physical Address

325 Biosciences East

Tucson Arizona 85721 USA

520-621-3045 520-621-8801

phil@nexus.srnr.arizona.edu 8:00am to 5:00pm Monday thru

Friday

**UNIX-ARC/INFO** 

### 1.14 Native Data Set Environment:

## 2 Data Quality Information

## 2.1 Attribute Accuracy

2.1.1 Attribute Accuracy Report:

### 2.2 Logical Consistency Report:

Coverage was built for point topology

2.3 Completeness Report:

## 2.4 Positional Accuracy

2.4.1 Horizontal Positional Accuracy

2.4.1.1 Horizontal Positional Accuracy Report:

#### 2.5 Lineage

2.5.1 Methodology

2.5.1.1 Methodology Type:

2.5.1.4 Methodology Citation:

8.1 Originator:

8.2 Publication Date

8.4 Title:

8.6 Data Presentation Form:

8.8.1 Publication Place:

8.8.2 Publisher:

8.9 Other Citation Details:

Aerial Video of Riparian Corridors in Saguaro National Park High 8mm Video

Tucson, Arizona



### 3 Spatial Data Organization Information

4 Spatial Reference Information

4.1 Horizontal Coordinate System Definition

4.1.2 Planar

4.1.2.2.1 Grid Coordinate System Name: Universal Transverse Mercator (UTM)

4.1.4.1 Horizontal Datum Name: North American Datum of 1927

4.1.4.2 Ellipsoid Name: Clarke 1866

5 Entity and Attribute Information

5.1 Detailed Description

5.1.2 Attribute

5.1.2.1 Attribute Label: Comment

5.1.2.2 Attribute Definition:

Comment item used to document unique features found at the site (i.e., pools, wildlife).

5.1.2 Attribute

5.1.2.1 Attribute Label: GPS Date

5.1.2.2 Attribute Definition:

Date site was sampled.

5.1.2 Attribute

5.1.2.1 Attribute Label: GPS Time

5.1.2.2 Attribute Definition:

Time of day site was sampled, .

5.1.2 Attribute

5.1.2.1 Attribute Label: Datafile

5.1.2.2 Attribute Definition:
Name of rover file.

5.1.2 Attribute

5.1.2.1 Attribute Label: Rel ID

5.1.2.2 Attribute Definition:

Primary key relating the point attribute table (PAT) to a data table that summarizes information collected at the site.

5.1.2 Attribute

5.1.2.1 Attribute Label: BLP ID

5.1.2.2 Attribute Definition:

Key field relating to a data table describing vegetation classifications based on the Brown, Lowe, and Pase System.

5.1.2.3 Attribute Definition Source:

See ripmetadata.doc

6 Distribution Information

6.1 Distributor

10.2 Contact Organization Primary

10.1.2 Contact Organization: Saguaro National Park

10.1.1 Contact Person: Pam Anning

10.3 Contact Position: Biological Science Technician



10.4 Contact Address 10.4.1 Address Type: Mailing and Physical Address 2700 N. Kinney Rd 10.4.2 Address: 10.4.3 City: Tucson 10.4.4 State or Province: Arizona 10.4.5 Postal Code: 85743 10.4.6 Country: USA 10.5 Contact Voice Telephone: 520-733-5174 10.7 Contact Facsimile Telephone: 520-733-5184 10.8 Contact Electronic Mail Address: pam anning@nps.gov 7:30am to 5:30pm Monday thru 10.9 Hours of Service: Thursday 7 Metadata Reference Information 7.1 Metadata Date: 19991231 7.2 Metadata Review Date: 7.4 Metadata Contact: 10.2 Contact Organization Primary 10.1.2 Contact Organization: Saguaro National Park 10.1.1 Contact Person: Pam Anning Biological Science Technician 10.3 Contact Position: 10.4 Contact Address 10.4.1 Address Type: Mailing and Physical Address 2700 N. Kinney Rd 10.4.2 Address: 10.4.3 City: Tucson 10.4.4 State or Province: Arizona 10.4.5 Postal Code: 85743 10.4.6 Country: USA 10.5 Contact Voice Telephone: 520-733-5174 10.7 Contact Facsimile Telephone: 520-733-5184 10.8 Contact Electronic Mail Address: pam anning@nps.gov 7:30am to 5:30pm Monday thru 10.9 Hours of Service:

Thursday



## Metadata for Riparian Vegetation - Arc/Info Coverage

Report Date: 01-Jan-2000

Metadata Data Set Name: Riparian

1 Identification Information

1.1 Citation Information:

8.1 Originator: Felicia M. Sirchia

8.2 Publication Date: 20000101

8.4 Title: Lower Elevation Riparian Vegetation

of Saguaro National Park

8.6 Data Presentation Form: Digital (Arc/Info Format)

8.8.1 Publication Place: Tucson, Arizona

8.8.2 Publisher: University of Arizona

1.2 Description

1.2.1 Abstract:

The riparian areas mapped consisted of major streams, Rincon Creek and Tanque Verde Wash, and the lower reaches (< 4000') tributary to the major streams.

1.2.2 Purpose:

The purpose of this coverage is to provide a baseline inventory of the lower reaches (< 4000') of riparian vegetation communities in Saguaro National Park East.

1.3 Time Period Of Content

9.1 Single Date/Time:

9.1.1 Calendar Date: 1999

1.3.1 Currentness Reference:

The year field work was conducted to produce the vegetation map.

1.4 Status

1.4.1 Progress: Completed 1.4.2 Maintenance and Update Frequency: As Needed

1.5 Geographic Extent

1.5.1 Description of Geographic Extent:

Saguaro National Park East Rincon Mountain District

1.6 Keywords

1.6.1.1 Theme Keyword Thesaurus:None1.6.1.2 Theme Keyword:Vegetation1.6.1.2 Theme Keyword:Land cover1.6.2.1 Place Keyword Thesaurus:None1.6.2.2 Place Keyword:Arizona

1.6.2.2 Place Keyword: Saguaro National Park

1.6.2.2 Place Keyword: Tucson

1.7 Taxonomy

1.7.1 Taxonomic Keywords: Plants

1.7 Taxonomy

1.7.2 Taxonomic Coverage



1.7.2.1 Specific Taxonomic Information

1.7.2.1.1 Kingdom: Plant

1.7.2.1.2 Division-Phylum: Interagency Taxonomic Information

System (ITIS)

1.8 Access Constraints:

None

1.9 Use Constraints:

None

1.10 Point of Contact

10.2 Contact Organization Primary

10.1.2 Contact Organization:University of Arizona10.1.1 Contact Person:Dr. Phil Guertin10.3 Contact Position:Associate Professor

10.4 Contact Address

10.4.1 Address Type Mailing and Physical Address

10.4.2 Address: 325 Biosciences East

10.4.3 City:Tucson10.4.4 State or Province:Arizona10.4.5 Postal Code:8572110.4.6 Country:USA

10.5 Contact Voice Telephone:520-621-304510.7 Contact Facsimile Telephone:520-621-8801

10.8 Contact Electronic Mail Address: phil@nexus.srnr.arizona.edu
10.9 Hours of Service: 8:00am to 5:00pm Monday thru

Friday

1.14 Native Data Set Environment: UNIX-ARC/INFO

2 Data Quality Information

2.1 Attribute Accuracy

2.1.1 Attribute Accuracy Report:

Vegetation types have been attributed and checked.

2.2 Logical Consistency Report:

All polygons have been checked for topology.

2.3 Completeness Report:

Each polygon has been attributed with a BLP Classification.

2.4 Positional Accuracy

2.4.1 Horizontal Positional Accuracy

2.4.1.1 Horizontal Positional Accuracy Report:

2.5 Lineage

2.5.1 Methodology

2.5.1.1 Methodology Type: Field work, on screen digitizing

2.5.1.4 Methodology Citation:

8.1 Originator: Felicia M. Sirchia



8.2 Publication Date 20000101

8.4 Title: Lower Elevation Riparian Vegetation

of Saguaro National Park

8.6 Data Presentation Form: Map/Digital
8.8.1 Publication Place: Tucson, Arizona
8.8.2 Publisher: University of Arizona

8.9 Other Citation Details:

2.5.2 Source Information

2.5.2.1 Source Citation:

8.1 Originator: Pamela J. Anning 8.2 Publication Date: 19970901

8.4 Title:

Historic Vegetation of Saguaro National Park 8.6 Data Presentation Form: Map

8.8.1 Publication Place:

Tucson, Arizona

8.8.2 Publisher:

Saguaro National Park

8.9 Other Citation Details:

2.5.2.3 Type Of Source Media: Paper

2.5.2.4 Source Time Period Of Content:

9.1 Single Date/Time

9.1.1 Calendar Date: 1937

2.5.2.4.1 Source Currentness Reference: Ground Condition

## 3 Spatial Data Organization Information

4 Spatial Reference Information

4.1 Horizontal Coordinate System Definition

4.1.2 Planar

4.1.2.2.1 Grid Coordinate System Name: Universal Transverse Mercator(UTM)

4.1.4.1 Horizontal Datum Name: North American Datum of 1927

4.1.4.2 Ellipsoid Name: Clarke 1866

5 Entity and Attribute Information

5.1 Detailed Description

5.1.2 Attribute

5.1.2.1 Attribute Label: BLP ID

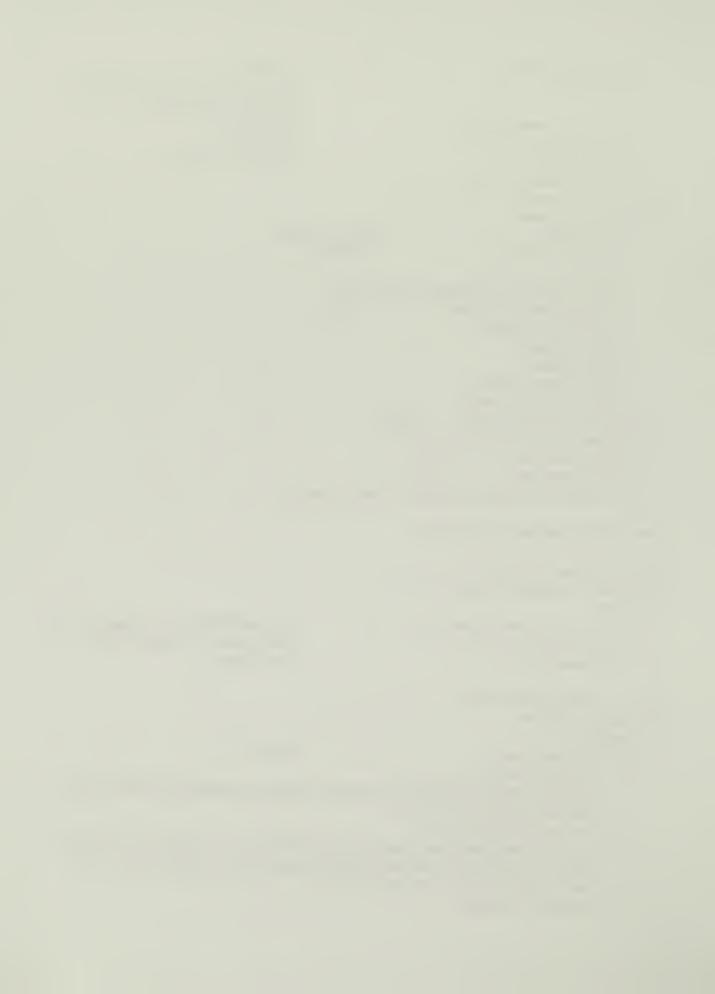
5.1.2.2 Attribute Definition:

Key field relating to a data table describing vegetation classifications based on the Brown, Lowe, and Pase System.

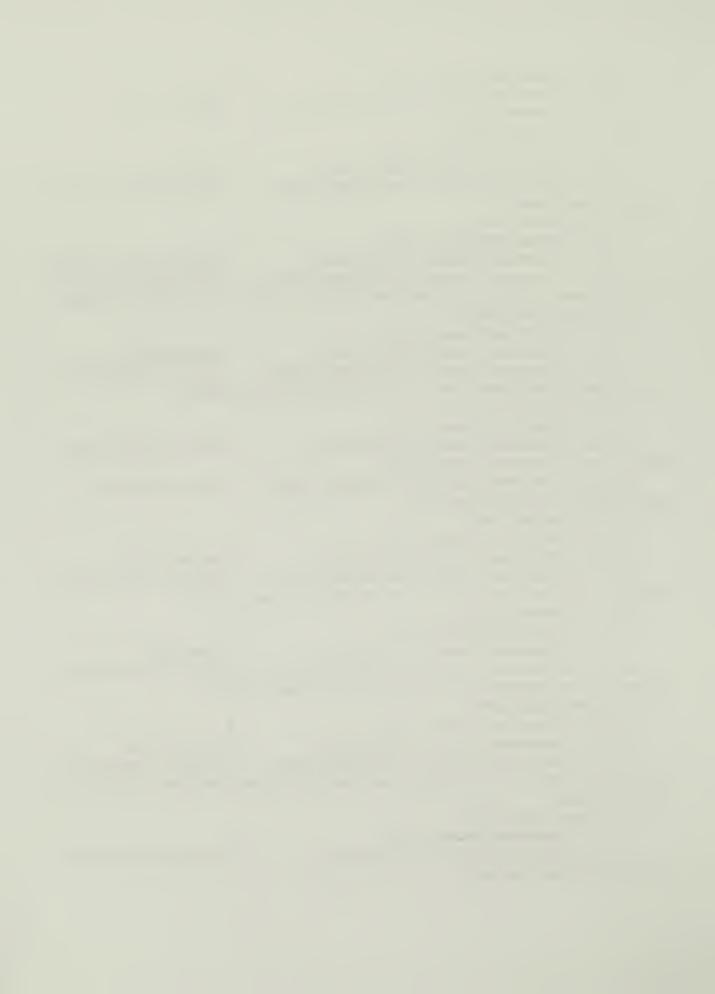
5.1.2.3 Attribute Definition Source:

The vegetation classification was devised by Brown, Lowe, and Pase as described in Biotic Communities Southwestern United States and Northwestern Mexico, 1994. University of Utah Press, Brown, D.E. (ed).

5.1.2.4.1 Enumerated Domain



5.1.2.4.1.1 Enumerated Domain Value:	1
5.1.2.4.1.2 Enumerated Domain Value Definition:	channel
5.1.2.4.1.3 Enumerated Domain Value Definition Source:	Stream channel
5.1.2.4.1 Enumerated Domain	
5.1.2.4.1.1 Enumerated Domain Value:	2
5.1.2.4.1.2 Enumerated Domain Value Definition:	developed
5.1.2.4.1.3 Enumerated Domain Value Definition Source:	Areas disturbed by urban or
agricultural development.	
5.1.2.4.1 Enumerated Domain	
5.1.2.4.1.1 Enumerated Domain Value:	3
5.1.2.4.1.2 Enumerated Domain Value Definition:	Populus fremonti – Salix spp.
5.1.2.4.1.3 Enumerated Domain Value Definition Source:	Areas that are dominated by
Populus fremonti, Salix spp. or both and characterized by warm-t	emperate climatic conditions.
5.1.2.4.1 Enumerated Domain	
5.1.2.4.1.1 Enumerated Domain Value:	4
5.1.2.4.1.2 Enumerated Domain Value Definition:	Populus fremonti
5.1.2.4.1.3 Enumerated Domain Value Definition Source:	areas that are dominated by
Populus fremonti and characterized by warm-temperate climatic of	conditions.
5.1.2.4.1 Enumerated Domain	
5.1.2.4.1.1 Enumerated Domain Value:	5
5.1.2.4.1.2 Enumerated Domain Value Definition:	Platanus wrightii-Fraxinus
velutina-Populus fremonti-mixed deciduous	č
5.1.2.4.1.3 Enumerated Domain Value Definition Source:	Areas co-dominated by
5.1.2.4.1.3 Enumerated Domain Value Definition Source:	Areas co-dominated by
•	Areas co-dominated by
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain	Areas co-dominated by
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value:	
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition:	6 Fraxinus velutina
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source:	6 Fraxinus velutina Areas that are dominated by
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Fraxinus velutina and characterized by warm-temperate climatic of	6 Fraxinus velutina Areas that are dominated by
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain	6 Fraxinus velutina Areas that are dominated by conditions.
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value:	6 Fraxinus velutina Areas that are dominated by conditions.
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition:	6 Fraxinus velutina Areas that are dominated by conditions.  7 Juglans major
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source:	6 Fraxinus velutina Areas that are dominated by conditions.  7 Juglans major Areas that are dominated by
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Juglans major and characterized by warm-temperate climatic conditions	6 Fraxinus velutina Areas that are dominated by conditions.  7 Juglans major Areas that are dominated by
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain Value: 5.1.2.4.1.1 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain Value: 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Juglans major and characterized by warm-temperate climatic cond 5.1.2.4.1 Enumerated Domain	6 Fraxinus velutina Areas that are dominated by conditions.  7 Juglans major Areas that are dominated by ditions.
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain Value: 5.1.2.4.1.1 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Juglans major and characterized by warm-temperate climatic cond 5.1.2.4.1 Enumerated Domain 5.1.2.4.1 Enumerated Domain Value:	6 Fraxinus velutina Areas that are dominated by conditions.  7 Juglans major Areas that are dominated by ditions.
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain Value: 5.1.2.4.1.1 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Juglans major and characterized by warm-temperate climatic cond 5.1.2.4.1 Enumerated Domain 5.1.2.4.1 Enumerated Domain Value 5.1.2.4.1.2 Enumerated Domain Value: 5.1.2.4.1.3 Enumerated Domain Value: 5.1.2.4.1.1 Enumerated Domain Value:	6 Fraxinus velutina Areas that are dominated by conditions.  7 Juglans major Areas that are dominated by ditions.  8 Mixed Narrowleaf
<ul> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees.</li> <li>5.1.2.4.1 Enumerated Domain Value:</li> <li>5.1.2.4.1.1 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source:</li> <li>Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain</li> <li>5.1.2.4.1.1 Enumerated Domain Value:</li> <li>5.1.2.4.1.2 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source:</li> <li>Juglans major and characterized by warm-temperate climatic cond 5.1.2.4.1.1 Enumerated Domain</li> <li>5.1.2.4.1.2 Enumerated Domain Value:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition:</li> </ul>	6 Fraxinus velutina Areas that are dominated by conditions.  7 Juglans major Areas that are dominated by ditions.  8 Mixed Narrowleaf Areas that are dominated by
<ul> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees.</li> <li>5.1.2.4.1 Enumerated Domain Value:</li> <li>5.1.2.4.1.2 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source:</li> <li>Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain</li> <li>5.1.2.4.1.1 Enumerated Domain Value:</li> <li>5.1.2.4.1.2 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source:</li> <li>Juglans major and characterized by warm-temperate climatic conditions</li> <li>5.1.2.4.1.1 Enumerated Domain</li> <li>5.1.2.4.1.2 Enumerated Domain Value:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source:</li> </ul>	6 Fraxinus velutina Areas that are dominated by conditions.  7 Juglans major Areas that are dominated by ditions.  8 Mixed Narrowleaf Areas that are dominated by
<ul> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees.</li> <li>5.1.2.4.1 Enumerated Domain</li> <li>5.1.2.4.1.1 Enumerated Domain Value:</li> <li>5.1.2.4.1.2 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source:</li> <li>Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain</li> <li>5.1.2.4.1.1 Enumerated Domain Value:</li> <li>5.1.2.4.1.2 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source:</li> <li>Juglans major and characterized by warm-temperate climatic conditions</li> <li>5.1.2.4.1.1 Enumerated Domain</li> <li>5.1.2.4.1.2 Enumerated Domain Value:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source:</li> </ul>	6 Fraxinus velutina Areas that are dominated by conditions.  7 Juglans major Areas that are dominated by ditions.  8 Mixed Narrowleaf Areas that are dominated by
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Juglans major and characterized by warm-temperate climatic cond 5.1.2.4.1 Enumerated Domain 5.1.2.4.1 Enumerated Domain Value: 5.1.2.4.1.1 Enumerated Domain Value Definition: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: mixed narrowleaf species characterized by warm-temperate climatexceeds tree cover. 5.1.2.4.1 Enumerated Domain	6 Fraxinus velutina Areas that are dominated by conditions.  7 Juglans major Areas that are dominated by ditions.  8 Mixed Narrowleaf Areas that are dominated by tic conditions and shrub cover
<ul> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees.</li> <li>5.1.2.4.1 Enumerated Domain Value:</li> <li>5.1.2.4.1.2 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source:</li> <li>Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain Value:</li> <li>5.1.2.4.1.1 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.2 Enumerated Domain Value Definition Source:</li> <li>Juglans major and characterized by warm-temperate climatic conditions</li> <li>5.1.2.4.1 Enumerated Domain Value:</li> <li>5.1.2.4.1.1 Enumerated Domain Value:</li> <li>5.1.2.4.1.2 Enumerated Domain Value Definition:</li> <li>5.1.2.4.1.3 Enumerated Domain Value Definition Source:</li> <li>mixed narrowleaf species characterized by warm-temperate climatexceeds tree cover.</li> <li>5.1.2.4.1 Enumerated Domain</li> <li>5.1.2.4.1 Enumerated Domain Value Definition Source:</li> </ul>	6 Fraxinus velutina Areas that are dominated by conditions.  7 Juglans major Areas that are dominated by ditions.  8 Mixed Narrowleaf Areas that are dominated by tic conditions and shrub cover
5.1.2.4.1.3 Enumerated Domain Value Definition Source: warm-temperate mixed deciduous trees. 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Fraxinus velutina and characterized by warm-temperate climatic of 5.1.2.4.1 Enumerated Domain 5.1.2.4.1.1 Enumerated Domain Value: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Juglans major and characterized by warm-temperate climatic cond 5.1.2.4.1 Enumerated Domain 5.1.2.4.1 Enumerated Domain Value: 5.1.2.4.1.1 Enumerated Domain Value Definition: 5.1.2.4.1.2 Enumerated Domain Value Definition: 5.1.2.4.1.3 Enumerated Domain Value Definition Source: mixed narrowleaf species characterized by warm-temperate climatexceeds tree cover. 5.1.2.4.1 Enumerated Domain	6 Fraxinus velutina Areas that are dominated by conditions.  7 Juglans major Areas that are dominated by ditions.  8 Mixed Narrowleaf Areas that are dominated by tic conditions and shrub cover



- 5.1.2.4.1.3 Enumerated Domain Value Definition Source: areas that are dominated by Cephalanthus occidentalis or Baccharis spp. characterized by warm-temperate climatic conditions and shrub cover exceeds tree cover.
  - 5.1.2.4.1 Enumerated Domain
    - 5.1.2.4.1.1 Enumerated Domain Value: 10
    - 5.1.2.4.1.2 Enumerated Domain Value Definition: Prosopis velutina
- 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Areas that are dominated by Prosopis velutina and characterized by tropical-subtropical climatic conditions.
  - 5.1.2.4.1 Enumerated Domain
    - 5.1.2.4.1.1 Enumerated Domain Value:
- 5.1.2.4.1.2 Enumerated Domain Value Definition: Prosopis velutina-mixed short tree
- 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Areas that are dominated by Prosopis velutina, Celtis reticulata, and Acacia spp. exhibiting shorter statures and characterized by tropical-subtropical climatic conditions
  - 5.1.2.4.1 Enumerated Domain
    - 5.1.2.4.1.1 Enumerated Domain Value:
    - 5.1.2.4.1.2 Enumerated Domain Value Definition: Populus fremonti/Salix Spp.
- 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Areas that are dominated by Populus fremonti, Salix spp. or both and characterized by tropical-subtropical climatic conditions.
  - 5.1.2.4.1 Enumerated Domain
    - 5.1.2.4.1.1 Enumerated Domain Value
    - 5.1.2.4.1.2 Enumerated Domain Value Definition Mixed Scrub
- 5.1.2.4.1.3 Enumerated Domain Value Definition Source: Areas that are dominated by mixed scrub species characterized by tropical-subtropical climatic conditions and shrub cover exceeds tree cover.
- 6 Distribution Information
- 6.1 Distributor
  - 10.2 Contact Organization Primary

10.1.2 Contact Organization: Saguaro National Park

10.1.1 Contact Person: Pam Anning

10.3 Contact Position: Biological Science Technician

10.4 Contact Address

10.4.1 Address Type: Mailing and Physical Address

10.4.2 Address: 2700 N. Kinney Rd

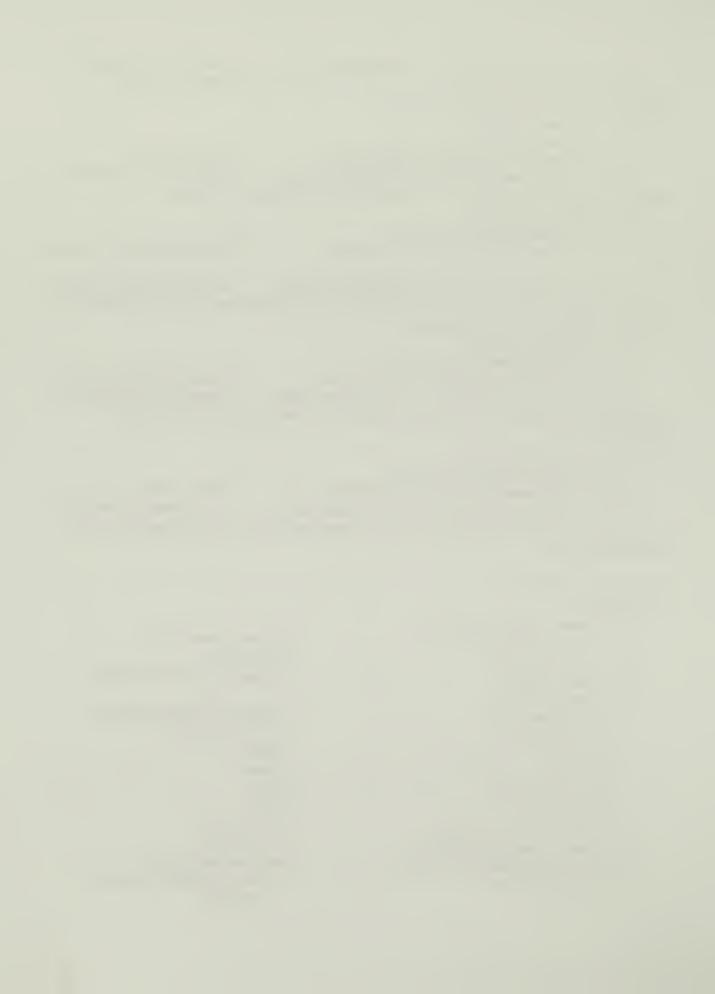
10.4.3 City:Tucson10.4.4 State or Province:Arizona10.4.5 Postal Code:8574310.4.6 Country:USA

10.5 Contact Voice Telephone: 520-733-5174 10.7 Contact Facsimile Telephone: 520-733-5184

10.8 Contact Electronic Mail Address: pam\_anning@nps.gov

10.9 Hours of Service: 7:30am to 5:30pm Monday thru

Thursday



7 Metadata Reference Information

7.1 Metadata Date: 19991231

7.2 Metadata Review Date:

7.4 Metadata Contact:

10.2 Contact Organization Primary

10.1.2 Contact Organization: Saguaro National Park

10.1.1 Contact Person: Pam Anning

10.3 Contact Position: Biological Science Technician

10.4 Contact Address

10.4.1 Address Type: Mailing and Physical Address

10.4.2 Address: 2700 N. Kinney Rd

10.4.3 City:

10.4.4 State or Province: Arizona 10.4.5 Postal Code: 85743

10.4.6 Country: USA

10.5 Contact Voice Telephone: 520-733-5174 10.7 Contact Facsimile Telephone: 520-733-5184

10.8 Contact Electronic Mail Address: pam anning@nps.gov

10.9 Hours of Service: 7:30am to 5:30pm Monday thru

Thursday

Tucson



## Metadata for Aerial Photo Points - Arc/Info Coverage

Report Date: 01-Jan-2000

Metadata Data Set Name: Ripphpts

1 Identification Information

1.1 Citation Information:

8.1 Originator: Felicia M. Sirchia

8.2 Publication Date: 20000101

8.4 Title: Aerial photo points of riparian

corridors in Saguaro National Park

8.6 Data Presentation Form: Digital (Arc/Info Format)

8.8.1 Publication Place: Tucson, Arizona
8.8.2 Publisher: University of Arizona

1.2 Description

1.2.1 Abstract:

Flight lines of aerial video taken at Saguaro National Park East. Points were generated from X,Y coordinates located in an ASCII text file obtained from...

1.2.2 Purpose:

To provide flight lines of the aerial video coverage of riparian areas of Saguaro National Park. Also used to link video footage to georeferenced points.

1.3 Time Period Of Content

9.1 Single Date/Time: September, 1999

9.1.1 Calendar Date: 1999

1.3.1 Currentness Reference:

The month and year of the flight.

1.4 Status

1.4.1 Progress: Completed
1.4.2 Maintenance and Update Frequency: Not Applicable

1.5 Geographic Extent

1.5.1 Description of Geographic Extent:

Saguaro National Park East Rincon Mountain District

1.6 Keywords

1.6.1.1 Theme Keyword Thesaurus: None

1.6.1.2 Theme Keyword:
Aerial Video
1.6.1.2 Theme Keyword:
Riparian Areas

1.6.2.1 Place Keyword Thesaurus: None 1.6.2.2 Place Keyword: Arizona

1.6.2.2 Place Keyword: Saguaro National Park

1.6.2.2 Place Keyword: Tucson

1.8 Access Constraints:

None

1.9 Use Constraints:

None



#### 1.10 Point of Contact

10.2 Contact Organization Primary

10.1.2 Contact Organization:

10.1.1 Contact Person:

10.3 Contact Position:

10.4 Contact Address

10.4.1 Address Type

10.4.2 Address:

10.4.3 City:

10.4.4 State or Province:

10.4.5 Postal Code:

10.4.6 Country:

10.5 Contact Voice Telephone:

10.7 Contact Facsimile Telephone:

10.8 Contact Electronic Mail Address:

10.9 Hours of Service:

University of Arizona Dr. Phil Guertin Associate Professor

Mailing and Physical Address

325 Biosciences East

Tucson Arizona 85721 USA

520-621-3045 520-621-8801

phil@nexus.srnr.arizona.edu 8:00am to 5:00pm Monday thru

Friday

#### 1.14 Native Data Set Environment:

# 2 Data Quality Information

## 2.1 Attribute Accuracy

2.1.1 Attribute Accuracy Report:

Checked against text file for accuracy

2.2 Logical Consistency Report:

Coverage built for point topology

2.3 Completeness Report:

Checked against text file for completeness

2.4 Positional Accuracy

2.4.1 Horizontal Positional Accuracy

2.4.1.1 Horizontal Positional Accuracy Report:

## 2.5 Lineage

- 2.5.1 Methodology
- 2.5.1.1 Methodology Type:
- 2.5.1.4 Methodology Citation:
  - 8.1 Originator:
  - 8.2 Publication Date
  - 8.4 Title:
  - 8.6 Data Presentation Form:
  - 8.8.1 Publication Place:
  - 8.8.2 Publisher:
  - 8.9 Other Citation Details:

UNIX-ARC/INFO

Aerial Video of Riparian Corridors in Saguaro National Park High 8mm Video Tucson, Arizona



# 3 Spatial Data Organization Information

4 Spatial Reference Information

4.1 Horizontal Coordinate System Definition

4.1.2 Planar

4.1.2.2.1 Grid Coordinate System Name: Universal Transverse Mercator (UTM)

4.1.4.1 Horizontal Datum Name: North American Datum of 1927

4.1.4.2 Ellipsoid Name: Clarke 1866

5 Entity and Attribute Information

5.1 Detailed Description

5.1.2 Attribute

5.1.2.1 Attribute Label: Time1

5.1.2.2 Attribute Definition:

Item indicating the time of day associated with the point, corresponds to time stamp on video.

5.1.2 Attribute

5.1.2.1 Attribute Label: Elev of plane

5.1.2.2 Attribute Definition: Altitude of plane.

6 Distribution Information

6.1 Distributor

10.2 Contact Organization Primary

10.1.2 Contact Organization: Saguaro National Park

10.1.1 Contact Person: Pam Anning

10.3 Contact Position: Biological Science Technician

10.4 Contact Address

10.4.1 Address Type: Mailing and Physical Address

10.4.2 Address: 2700 N. Kinney Rd

10.4.3 City:Tucson10.4.4 State or Province:Arizona10.4.5 Postal Code:85743

10.4.5 Postal Code: 85/43 10.4.6 Country: USA

10.5 Contact Voice Telephone: 520-733-5174 10.7 Contact Facsimile Telephone: 520-733-5184

10.8 Contact Electronic Mail Address: pam\_anning@nps.gov

10.9 Hours of Service: 7:30am to 5:30pm Monday thru

Thursday

7 Metadata Reference Information

7.1 Metadata Date: 19991231

7.2 Metadata Review Date:

7.4 Metadata Contact:

10.2 Contact Organization Primary

10.1.2 Contact Organization: Saguaro National Park

10.1.1 Contact Person: Pam Anning



10.3 Contact Position:

10.4 Contact Address

10.4.1 Address Type:

10.4.2 Address:

10.4.3 City:

10.4.4 State or Province:

10.4.5 Postal Code:

10.4.6 Country:

10.5 Contact Voice Telephone:

10.7 Contact Facsimile Telephone:

10.8 Contact Electronic Mail Address:

10.9 Hours of Service:

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2700 N. Kinney Rd

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7:30am to 5:30pm Monday thru

Thursday



# Appendix E

**Riparian Vegetation Types** 

in

Saguaro National Park East

Appendix L.

Riparian Vegetation Types

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Seguaro National Park East

Nomenclature of biotic communities of Nearctic and adjacent Neotropical North America with community (Series) and association examples for the North American Southwest that are known or expected to exist in Saguaro National Park East, Arizona, according to the system of biotic community classification developed by Brown, Lowe, and Pase (1994).

# WARM TEMPARATE WETLANDS

**Cottonwood-Willow Series** 

BIOGEOGRAPHIC REALM: Nearctic

VEGETATION: Nearctic Wetland Vegetation FORMATION-TYPE: Swampforest; Riparian Forest

CLIMATIC ZONE: Warm Temperate Swamp & Riparian Forests

REGIONAL FORMATION: Interior Southwestern Riparian Deciduous Forest & Woodland

SERIES: Cottonwood-Willow

CLASSIFICATION CODE: 223.21

#### **DESCRIPTION:**

This series is a characteristic of stream features throughout the southwest's warm-temperate zones at elevation ranges of 1000-1750 meters. Typically found in alluvial sands, clays, and gravels on flood plains periodically subjected to spring floods. Characteristic species include *Populus fremonti* and *Salix gooddingii*. Understory species include *Baccharis* spp., *Acacia greggi*, *Celtis* spp., and *Vitis arizonica*.

#### **ASSOCIATIONS:**

223.211	Populus fremonti – Salix spp.	
223.212	Populus fremonti	

# Mixed Broadleaf Series

BIOGEOGRAPHIC REALM: Nearctic

VEGETATION: Nearctic Wetland Vegetation FORMATION-TYPE: Swampforest; Riparian Forest

CLIMATIC ZONE: Warm Temperate Swamp & Riparian Forests

REGIONAL FORMATION: Interior Southwestern Riparian Deciduous Forest & Woodland

SERIES: Mixed Broadleaf

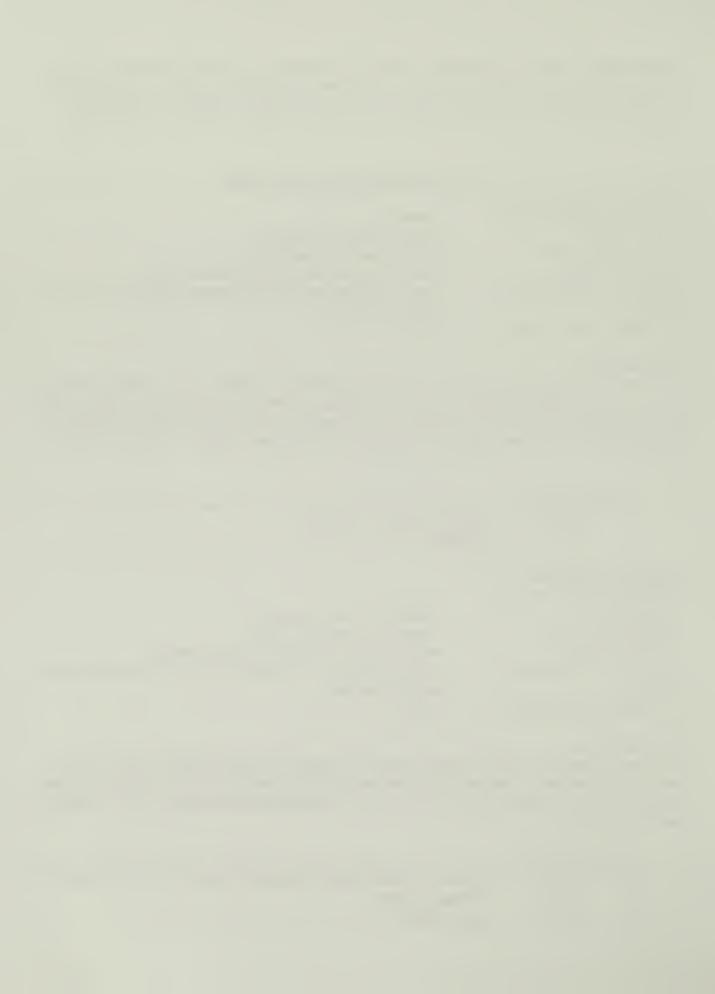
CLASSIFICATION CODE: 223.22

#### **DESCRIPTION:**

This series is found at elevation ranges of 1000-1750 meters along rubble-bottomed perennial and near-perennial streams. Characteristic species *include Populus fremonti*, *Salix gooddingii*, *Fraxinus velutina*, *Platanus wrightii*, *Juglans major*, and *Celtis reticulata* with understory species of *Rhus* spp. and *Vitis arizonica*.

#### **ASSOCIATIONS:**

223.221	Platanus wrightii-Fraxinus velutina-Populus fremonti-mixed deciduous
223.223	Fraxinus velutina
223.225	Juglans major



Mixed Narrowleaf Series

BIOGEOGRAPHIC REALM: Nearctic

VEGETATION: Nearctic Wetland Vegetation FORMATION-TYPE: Swampscrub; Riparian Scrub

CLIMATIC ZONE: Warm Temperate Swamp & Riparian Scrubs

REGIONAL FORMATION: Interior Southwestern Swamps and Riparian Scrub

SERIES: Mixed Narrowleaf

CLASSIFICATION CODE: 233.21

#### DESCRIPTION:

This series is found in elevation ranges of approximately 1000-1750 meters and may constitute a riparian understory or prelude for the riparian forests. Typical species found in this series include *Prosopis velutina*, *Acacia greggii*, *Parkinsonia* spp., *Chilopsis linearis*, *Celtis reiticulata*, *Celtis pallida*, *Baccharis salicifolia*, and *Cephalanthus occidentalis*. Also, based on previous mapping of the expansion area, it was found that *Gossypium thurberi*, *Jatropha cardiophylla*, *Muhlenbergia* spp., *Celtis pallida*, and *Lysiloma microphylla* are contributors to this vegetation type.

#### ASSOCIATION:

233.211 Cephalanthus occidentalis-Baccharis glutinosa-mixed scrub

### TROPICAL-SUBTROPICAL WETLANDS

Mesquite Series

BIOGEOGRAPHIC REALM: Nearctic

VEGETATION: Nearctic Wetland Vegetation FORMATION-TYPE: Swampforest; Riparian Forest

CLIMATIC ZONE: Tropical-Subtropical Swamp, Riparian & Oasis Forests REGIONAL FORMATION: Sonoran Riparian Deciduous Forests & Woodlands

SERIES: Mesquite

CLASSIFICATION CODE: Not defined at this time

#### DESCRIPTION:

Typically found below 1000 meters, this vegetation type is often referred to as a mesquite bosque. Characterized by large, numerous mesquites over 6 meters typically located on alluvial sands and old floodplains.

ASSOCIATION: None defined

Mesquite Series

BIOGEOGRAPHIC REALM: Nearctic

VEGETATION: Nearctic Wetland Vegetation FORMATION-TYPE: Swampforest; Riparian Forest

CLIMATIC ZONE: Tropical-Subtropical Swamp, Riparian & Oasis Forests

REGIONAL FORMATION: Sonoran Riparian & Oasis Forests

SERIES: Mesquite



**CLASSIFICATION CODE:** 

224.52

DESCRIPTION:

This series is found in streams and springs below 1000 meters in elevation. Typical species include *Prosopis velutina*, *Celtis reticulata*, *Baccharis salicifolia*, *Baccharis sarothroides*, and *Acacia greggii*. With understories containing Ziziphus obtusifolia, Lycium spp., and Atriplex spp. These plant associations are more mesic in nature with small statures.

# **ASSOCIATIONS:**

224.521

Prosopis velutina

224.522

Prosopis velutina-mixed short tree

**Cottonwood-Willow Series** 

BIOGEOGRAPHIC REALM:

Nearctic

**VEGETATION:** 

Nearctic Wetland Vegetation Swampforest; Riparian Forest

FORMATION-TYPE: CLIMATIC ZONE:

Tropical-Subtropical Swamp, Riparian & Oasis Forests

**REGIONAL FORMATION:** 

Sonoran Riparian & Oasis Forests

SERIES:

Cottonwood-Willow

CLASSIFICATION CODE:

224.53

#### **DESCRIPTION:**

This series is found in perennial and intermittent streams and springs below 1000 meters in elevation. Typical species include *Populus fremontii*, *Salix gooddingii*, and *Acacia greggii*. Understory species may include *Baccaris* spp. and *Vitis arizonica*.

# **ASSOCIATION:**

224.531

Populus fremonti/Salix goodingii

Mixed Scrub Series

BIOGEOGRAPHIC REALM:

Nearctic

VEGETATION:

Nearctic Wetland Vegetation

FORMATION-TYPE:

Swampscrub; Riparian Scrub Tropical-Subtropical Swamp & Riparian Scrubs

CLIMATIC ZONE: REGIONAL FORMATION:

Sonoran Riparian Scrubland

SERIES:

Mixed Scrub

**CLASSIFICATION CODE:** 

234.71

#### **DESCRIPTION:**

This series is found in and along drainages less than 1000 meters in elevation. Scrublands are of low to medium height (1.5-3.0 meters) and dense. Typical species include *Acacia greggii*, *Baccharis salicifolia*, *Celtis pallida*, *Chilopsis linearis*, *Hymenoclea monogyra*, and *Prosopis velutina* with *Baccharis salicifolia* found within the stream channel.

ASSOCIATION: Classified only to series level



# **NON-VEGETATION**

**CLASSIFICATION CODE:** 

Channel

DESCRIPTION:

This code was given to those areas lacking vegetation and falling within the stream corridor.

**CLASSIFICATION CODE:** 

Developed

**DESCRIPTION:** 

This code was used to describe areas that were contiguous with the riparian vegetation mapped but were clearly disturbed by urban or agricultural development.





